ECONOMICS OF SMALL AND SHARECROPPER FARMS UNDER RISK IN THE SERTAO OF NORTHEASTERN BRAZIL

By

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Abstract of Dissertation Presented to the Graduate Council
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The purpose of this study was to improve the understanding of the economic relationships between landowner and sharecropper in the semi-arid region of Northeastern Brazil. The specific objectives were, for small and sharecropper farms, to determine (a) the risk associated with different enterprise combinations; (b) an efficient set of farm plans for three different farm sizes which minimize income variance for given levels of expected income; and (c) the effects of changes in sharecropping conditions, dropping cotton production, changes in cotton prices, and reductions in credit availability on employment, enterprise combinations, output, incomes, and risk.

The municipios (counties) of Caicó and Florânia in the State of Rio Grande do Norte were selected as the study area because of their representative characteristics of the semi-arid region. Most of the primary data used were taken from a random sample of farms conducted in 1973/1974 by the SUDENE/World Bank project.

Linear and quadratic programming models were used to estimate minimum risk (income variance) for given levels of income for each farm

size and for the sharecropper unit. The programming models account for major relationships between sharecroppers and landowners such as production activities on owner-operated and sharecropped parts of the farm, sharecroppers' share of production, market margin on sharecroppers' production, sharecropper labor (sujeicão labor), and sharecropper consumption. A sharecropper sub-model was developed and its optimized results were introduced as activities in the medium and large farm models. The basic assumption underlying the models was that the sharecropper has some decision-making power within the framework of the sharecropping contract.

Activities involving cotton were less risky than other crop activities. The level of risk increased at an increasing rate as the level of expected income increased. Income from cattle also had a relatively low variance. Risk-aversion decreased as size of farm increased. Thus, riskier farm plans were chosen by farmers as farm size increased. However, sharecroppers were not risk averse. Land was a restrictive factor only for sharecroppers and small farmers. Labor was a limiting factor for medium and large farmers. For small farmers, labor was restrictive only in critical months. Financial resources, with the exception of sharecroppers, were not a limiting factor.

Results from the sensitivity analysis show that, when sharecroppers were excluded as a source of labor, higher risks were incurred by medium and large farmers. Deleting cotton from the farm plans, and a consequent shift to pasture land, would result in less income at given levels of risk. When cotton price was increased 15 percent, more land was allocated to sharecroppers, total cotton area increased, but owner-operated cotton decreased. A reduction in credit by 50 percent would have no

effect on small and medium farmers and very little effect on large farms. A reduction of 75 percent in credit would affect all farms, but the major impact was a substantial reduction in the cattle activity and in the income potential on the large farm.

Opportunities for increasing incomes and reducing risks by reallocating existing resources are very limited. Thus, there is a need for major research efforts to develop new opportunities.

CHAPTER I
INTRODUCTION

The Brazilian Northeast covers an area between two and three times the size of Texas and has a population of approximately 30 million people. Approximately 60 percent of the population lives in semi-arid areas with generally infertile soils. These areas are subject to periodic, devastating droughts with accompanying high risks to farmers. Land ownership is highly concentrated in large ownership units and many of the rural poor are landless, often working in some form of sharecropping.

Census data in Table 1 show the distribution of land by farm size in Brazil and in the Northeast in 1960 and 1970. In 1970 Northeast Brazil had 45 percent of all farms in Brazil and 60 percent of the farms with less than 10 hectares. As the data in Table 1 indicate, the number of farms in the Northeast with under 10 hectares increased from 873,124 to slightly less than 1.5 million between 1960 and 1970. Although these farms constituted 68 percent of the number of farms in the Northeast in 1970, they contained only 5 percent of the land area. In comparison, the farms of 1,000 hectares or more accounted for 0.4 percent of the farms and 27 percent of the total area of the Northeast. Even though the varying quality of land, and especially the large area of infertile land on many large farms, is not identified in these data, it is well known that the land resource of the Northeast is poor in relation to the other parts of Brazil. This condition aggravates the

Table 1. Distribution of land by farm sizes, Brazil and Northeast, 1960-1970

Size in hectares	1960				1970			
	Number	Percent	Area (1,000 ha)	Percent	Number	Percent	Area (1,000 ha)	Percent
Brazil	3,337,769	100.00	249,862	100.00	4,924,019	100.00	249,145	100.00
Under 10	1,495,020	44.79	5,952	2.38	2,519,630	51.17	9,083	3.08
10-99	1,491,415	44.68	47,566	19.04	1,934,392	39.28	60,070	20.43
100-999	314,831	9.43	86,029	34.43	414,746	8.42	108,743	36.97
1,000-9,999	30,883	0.93	71,421	28.88	35,425	0.72	80,059	27.22
Over 10,000	1,569	0.05	38,893	15.57	1,416	0.03	36,190	12.30
Unclassified	4,023	0.12	---	---	18,377	0.37	---	---
Northeast	1,408,114	100.00	62,989	100.00	2,206,788	100.00	74,299	100.00
Under 10	873,124	62.01	2,746	4.36	1,499,625	67.95	4,069	5.48
10-99	421,183	29.91	13,744	21.82	560,903	25.42	17,821	24.07
100-999	105,388	7.48	27,544	43.73	126,124	5.72	32,049	43.20
1,000-9,999	7,483	0.53	15,363	24.39	8,501	0.38	17,363	23.39
Over 10,000	179	0.01	3,592	5.70	160	0.01	2,867	3.86
Unclassified	757	0.05	---	---	11,475	0.52	---	---

SOURCE: Calculated from Census data, 1960-1970.

poverty problem of the small farms of the Northeast when compared with the small farms of the rest of the country.

As a reflection of the very unequal distribution of land-holdings, the distribution of capital and wealth is also highly concentrated in the lands of a small percentage of the population. An analysis by SUDENE [1976], that takes into account differences in soil fertility and in the stock of fixed capital, shows that the distribution of wealth incorporated into land is even more uneven than the distribution of land itself. In addition, the distribution of income among landowners is as unequal as the distribution of land [SUDENE, 1976].

In spite of the picture described above with respect to the very small landowner, the most severe poverty problems are found among those who do not own land but comprise over 70 percent of the rural labor force [SUDENE, 1976]. This group of the agricultural labor force makes up the great majority of those persons in the lowest part of the Northeast's income distribution. This landless population is employed in various forms of tenancy and wage labor of which the largest subgroups are composed of temporary laborers and sharecroppers [Johnson, 1971]. This picture is shown in Table 2, where employed population in agriculture is classified by occupational categories in states of the Northeast.

From the standpoint of what has been described above, and its implications, one must conclude that any program that aims to improve rural productivity and income levels must consider the economic and social relations of the environment in which it is conducted.

According to the World Bank the rural per capita income of Northeast Brazil in 1974 was less than US $225, compared with a national average per capita income of US $815. The government has made several

Table 2. Estimates of employed population in agriculture, by class of labor and state, Northeast Brazil, 1973

State	Family labor	Permanent labor	Temporary labor	Sharecroppers	Total
Rio Grande do Norte	115,182	33,152	97,604	66,980	312,919
Paraíba	216,003	151,721	204,568	41,682	613,974
Pernambuco	230,540	301,056	330,092	293,238	1,154,926
Ceará	284,931	268,017	242,013	290,337	1,085,298
Piauí	142,837	35,709	201,447	140,512	520,505
Maranhão	101,154	339,199	274,875	430,579	1,205,807
Alagoas	74,365	86,511	115,497	183,352	459,725
Sergipe	80,490	20,138	142,640	49,442	292,710
Bahia	430,580	300,210	711,590	766,550	2,208,930
Northeast	1,676,142	1,595,714	2,320,326	2,262,672	7,854,794
Percent	21.3	20.3	29.6	28.8	100.0

SOURCE: SUDENE [1976, p. 103.].

attempts, mainly through industrialization (supported by fiscal and monetary incentives) and several social programs, to improve this situation and to reduce the economic gap between the Northeast and Southeast regions of Brazil. However, the effectiveness of these attempts has been limited and, to some extent, a disappointment, especially in the agricultural sector.

Morley [1974] suggests that this situation may be a result of the rapid growth strategy followed by the Brazilian government since 1967. The adoption of this strategy, implicitly focusing on a Lewis [1963] type of model, would maximize the creation of high productivity jobs in the nonagricultural sectors. This objective would be achieved by creating the conditions for the most rapid possible aggregate growth of the economy. As a consequence, the industrial expansion would gradually absorb all the underemployed labor and, as a result, a labor shortage would develop and a larger share of income would be shifted to labor. Unfortunately, this type of policy has failed to recognize the importance of agriculture. Government priorities and public policy were directed toward industrialization, considered as the modern and dynamic sector, while agriculture was neglected. Foreign exchange controls, import restrictions, indirect taxation, and product price controls, generally detrimental to the agricultural sector, have been only partially offset by low interest rates on credit and factor subsidies as agriculture has been effectively squeezed to extract a surplus for industrialization [Furtado, 1967; Ohio State University, 1975]. The agricultural sector has been relegated to a more passive role in the development process.

> Structural changes such as agrarian reform, improvements in rural education, and increased support for research and extension have been minimal compared to frequent intervention

> into markets designed to maintain a delicate balance between low food prices for consumers and sufficient stimulus to farmers to expand output. [Ohio State University, 1975, p. 12-1]

Even though employment in manufacturing has been growing at 4.5 percent per year and urban employment overall has grown at 3.9 percent [IPEA, 1973], the adequacy of this growth strategy as an employment and distribution policy has been questioned.[1] In too many cases, individual's earnings are determined by the job one holds more than by one's formal education or training [Morley, 1974]. It has also been suggested that the widening wage structure in Brazil reflects an educational bottleneck [Schuh, 1976]. The problem is that the educational system responds very slowly to market signals. It is a sector where externalities are important. Therefore, in part the market is unable to match available skills and abilities because the educational and training system is not able to respond rapidly enough to provide the appropriate skills. In this case, the people who most need help are the big majority of poor uneducated agricultural laborers of the Northeast. It is difficult for the poor to see how a policy of rapid growth in the South or even in the three big urban concentrations of the Northeast (Recife, Salvador, and Fortaleza) will ever reach them. Assuming that the linkages between the labor markets in which these people work and the modern industrial labor market are weak, the demand for industrial labor can be increased without changing the labor structure. As a result, this type of expansion may merely lead to shortages and an

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[1] In recent years the unsatisfactory concentration of Brazilian income distribution has become a polemic and fashionable issue. Even though its causes and interpretations are questionable, its unsatisfactory concentrations and further deterioration are now accepted facts by many economists [Langoni, 1973; Bacha _et al_., 1972; Fishlow, 1972; Tavares, 1971].

accelerated replacement of labor by capital, rather than to the expected trickle down of jobs and benefits.

Another problem related to this simple growth strategy is its reliance on market signals [Morley, 1974]. Especially for the Northeast, desired actions in policy terms have tended to depend on the inducement of profit incentives.[2] Therefore, depending on how sensitive investment is to profit differentials, regressive implications for the distribution of income and employment may occur. If, in order to induce private enterprise to create jobs, enormous tax exemptions have to be given, then a worsening in income distribution may be the price paid for rapid employment growth.

In addition to the considerations mentioned above, one must always visualize the importance of the agricultural sector in the economy of the Northeast with respect to income and employment generation. In a region characterized by a semi-subsistence agriculture and primitive markets (except for cash crops such as sugarcane, cotton, and cocoa), a rapid growth strategy is inadequate in the sense that it does not include this important part of the economy and, hence, agricultural performance is not affected.

As several studies indicate [Patrick, 1972; Goodman and Albuquerque, 1971], the agricultural sector of the Northeast during the period 1948

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[2]Article 34/18 System (named after Article 34 of Law 3995, December 1961, approving the First SUDENE Master Plan and Article 18 of Law 4239, June 1963, approving the Second Master Plan) would also permit any national corporation to deposit up to 50 percent of its income tax due in the Bank of Northeast Brazil (BNB) for purposes of investing in industrial, agricultural, or telecommunications projects in the Northeast, provided that such project was approved by the SUDENE as being of benefit to the region [SUDENE, 1966; U.S. Brazilian Embassy, 1966; U.S. Brazilian Embassy, 1967; Sutherland, 1967].

to 1969 has experienced growth but very little economic development;[3] also, the Region as a whole has not shown any significant structural change as a result of government policies toward industrialization. There was no change in the income structure in this period in contrast with the Southeast, especially in contrast with São Paulo [Patrick, 1972]. From 1948 to 1969, even though the agricultural production of the Northeast increased at a higher average annual rate (4.7 percent) than the agricultural production of Brazil (4.2 percent), there was no major improvement in productivity, income, quality of life, or wages in the agricultural sector [Patrick, 1972]. The increase in agricultural production was a result of the enlargement of cultivated area, an increase in labor use, and an increase in livestock production, rather than an increase in yields per hectare.

As a result of this poor performance and given that one of the major concerns of government policy is to reduce the economic and social gap between the Northeast and the rest of the country, the emphasis of government programs is beginning to shift considerably. New programs[4] are being developed and are aimed at improving rural productivity and incomes in order to achieve specific goals of the II National Development Plan. There is an emphasis on employment and human resources:

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[3]Economic growth refers to a sustained increase in per capita income while economic development refers to the economic and structural changes that are conducive to growth [Hagen, 1975]. In this context, structural changes may include social and political systems, economic institutions, and in technology. Thus, the objectives of development includes increases in productive capacity and productive employment of labor and more equitable distribution of the income and other social benefits.

[4]One of the new programs, POLONORDESTE, involves federal funding of US$700 million over the period 1975-79.

> As already indicated, there will be a considerable reduction in underemployment, and in the population included in the absolute poverty group, becasue productivity and income will rise to higher levels. The reserve of underemployed labor in the interior of the Northeast could become much reduced. [Brazil, 1974, pp. 131-132]

> Migration to the Center-South will tend to fall as a result of the greater absorptive capacity of other macroeconomic poles. [Brazil, 1974, p. 132]

Government policy and programs must also consider the possible effects of potential changes on employment, income, and social conditions of sharecroppers and temporary laborers. Any change or transformation of agriculture which overlooks this important economic and social component may introduce serious problems instead of improving the overall situation.

Earlier, such problems were confronted in São Paulo where modernization of agriculture was achieved at the expense of the landless agricultural laborers. Through the utilization of capital intensive technological packages, landless agricultural workers were expelled from the farm and either transformed into nomad agricultural workers, "Bóia-Fria", or moved to the slums of the big cities [D'Íncao e Mello, 1975].

Seixas Neto [1976], using two CES production functions, studied the nature of technological changes for the 1950-74 period for the agricultural sector of the State of São Paulo. The main conclusion of his study with respect to labor and equipment ratios was that technology for the entire period was capital intensive. For the 1950-60 period, technology was classified as neutral and for 1960-74 it was classified as capital intensive. With respect to the labor and fertilizer ratio in the entire 1960-74 period, technology was found to be capital intensive, even though evidence that, at least up to the 1960's, technology was essentially land intensive.

Land, in more recent years, was found to be scarce in relation to labor. As a result, the study suggests that efforts should be directed toward land saving technologies [Seixas Neto, 1976].

An overview study of the agricultural sector of the State of Pernambuco, presented by Soares [1976], concludes that no importance has been given to the small farmer whom he considers one of the most important agents in the agricultural production system. He argues against any capital intensive technology because growth of the nonagricultural sector is not sufficient to absorb released labor. Present credit policies are ineffective in the medium and long run because of their inability to promote self-sustained development since, in general, profits are transfered and invested outside the agricultural sector. A reorientation of credit policies toward small farmers was suggested as a way to increase productivity in agriculture. Among other conclusions, the study points out the danger of indiscriminate modernization and fertilization. As an alternative, it proposes the diffusion of simple techniques such as double cropping, mulching, and use of selected seeds [Soares, 1976].

A study conducted in Pernambuco on supply and consumption of food for the metropolitan area of Recife describes the deterioration of urban living conditions that was due to the incapacity of the city to keep pace with the increasing demand for basic infrastructure services as a result of the growing rates of rural to urban migration [SUDENE and UFPe, 1975]. Poor housing conditions and an inadequate piped water supply for the majority of the low income groups are some examples of the incapacity of municipal governments to supply basic infrastructure services. The sewage system serves only 30 percent of the population of the

metropolitan area [SUDENE and UFPe, 1975]. If the increasing demands upon the urban infrastructure are not met, the maintenance of a government policy which causes further displacement of labor from the land will lead to a virtual collapse of existing services in the urban sector.

Unfortunately, with few exceptions, agricultural economic research in Brazil has traditionally been based on data obtained from medium and large landowners [Schuh, 1970]. As a result, our understanding of the problem arising from the poverty that exists may be incomplete and biased. It is only recently that there has been a shift towards the inclusion into economic analysis of information and data originally furnished by sharecroppers and other low income groups in agriculture [EMBRAPA, 1975; Patrick and Carvalho Filho, 1975].

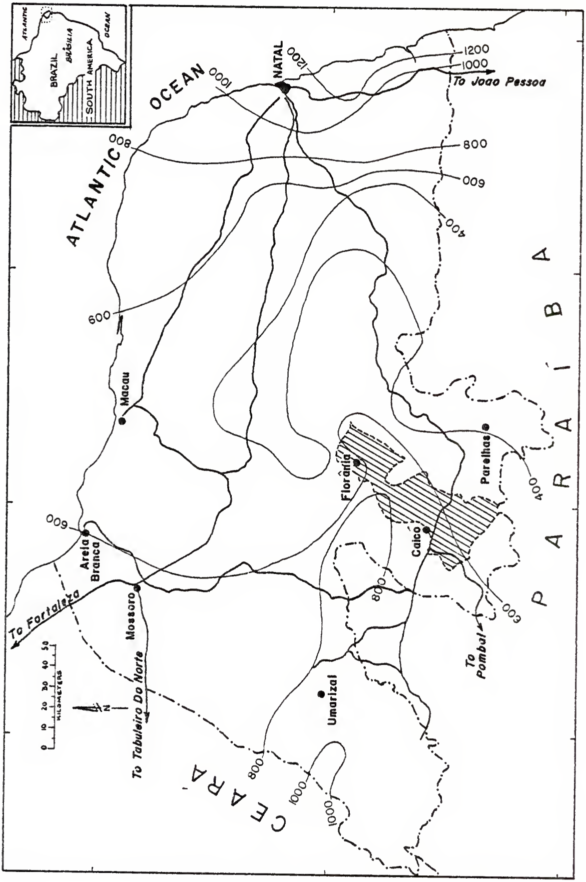
Since information concerning sharecroppers is vital for economic analysis of such systems, it is highly desirable to make use of a specific sample of sharecroppers. Given the prevailing socio-economic conditions of the Northeast and the past experience of the modernization of agriculture in the South, especially in São Paulo, there is a vital need for a better understanding of the production systems and their interrelations with income and employment of low-income groups in agriculture.

Area of Study

The area selected for the present study is the Semi-Arid Zone (Sertão Semi-Árido), the drought-prone, sub-region of Northeast Brazil. The sample data were taken in an area of the state of Rio Grande do Norte (Figure 1). In this region, the high variability of rainfall

Figure 1. Location of the study area, rainfall, and infrastructure, Rio Grande do Norte, Brazil

//////////	Study area
————	Asphalt Roads
—·—·—·—	State Boundaries
—800—	Rainfall Isohyets (in millimeters)


ATLANTIC OCEAN
NATAL
To Joao Pessoa
Macau
Areia Branca
Mossoro
To Fortaleza
To Tabuleiro Do Norte
Umarizal
Florania
Caico
Parelhas
To Pombal
PARAÍBA
CEARÁ
BRAZIL
BRÁSILIA
SOUTH AMERICA
ATLANTIC
OCEAN
KILOMETERS
0 10 20 30 40 50
N
1200
1000
800
600
400
300

poses extreme risks for agriculture. Its average yearly rainfall is 745 mm with 67 percent of the rain concentrated in four months. The typical production system involves tree cotton (cash crop), corn and beans, and beef cattle [Kutcher and Scandizzo, 1976]. Small farmers and/or sharecroppers are typically engaged in crop production while large landowners are mainly concerned with cattle. It is common to observe beans and corn interplanted with cotton, beans interplanted with corn, and cotton grown alone. When asked the reason for using these practices, farmers reply by saying that they save labor and that it reduces the risk of total crop failure. The most frequently observed inputs involve only labor and land. Seeds are saved at each harvest to be used in the next production period. Fertilizers are not used, and insecticides and pesticides are rarely applied. In addition, it is in this part of the Northeast where the relationship of complete dependency between the subsistence peasants and the landowner is much more perceptible, where the landlord provides a bundle of services unavailable outside the structure of the *fazenda* [Johnson, 1971].

Purposes and Objectives

The general purpose of this research is to analyze the economic relations of sharetenancy in Northeast Brazil, with special emphasis on the interrelationships between the landowner and the sharecropper economy, in order to develop a more accurate understanding of these relationships. Objectives are to determine:

(a) The relative risk of different enterprise combinations;

(b) The optimal resource uses and enterprise combinations for three different farm sizes, taking into account the risk associated with enterprise gross income variability;

(c) Efficient sets of farm plans for the three different farm sizes that would minimize income variance for given levels of expected income; and

(d) The effects of changes in sharecropping conditions, removing cotton as an enterprise, changes in cotton prices and reduction in the amount of available credit on labor employment, land use, output, and the level and variability of incomes for different farm sizes.

It is believed that one of the major problems in Northeast Brazil is the insufficient understanding of the economic interrelationship between the landowner and the sharecropper in the farm economy. Therefore, in the present study, models are developed to describe this interrelationship in which the decision-making process (resource allocation and production) both of the landowner and of the sharecropper are taken into account explicitly.

A basic assumption underlying the models used in this study is that the sharecropper has some decision-making power within the framework of the sharecropping contract and in influencing the nature of the contract. The typical sharecropping contract in the study area is negotiated directly between landowner and sharecropper and includes several components that are discussed in more detail in the next chapter. However, even though the contract places some limitations on the decision-making process by the sharecropper and the landowner has considerable economic and political power, the sharecropper is free to make his own choice with respect to what crops will be combined with cotton (mixed-cropping choice), the crop patterns that will meet his family consumption requirements, the amount of temporary labor that will be hired, and the management of the plot. This perception of farm decision making, which also acknowledges the role of the landowner as the central decision maker, is in agreement with the theory and historical development of

sharecropping [Reid, 1975] and with another recent empirical study conducted in this region [Kutcher and Scandizzo, 1976].[5]

Since the implicit goal of the research is to identify ways and means to improve income and employment conditions in the Region, the question then boils down to choosing policies that are relevant and feasible. However, given the scope of this study, only a few potential policies will be simulated. In this sense, the specific objectives of the research will be met by the simulation of these specific policies and examining their effects on resource use, output, and income level and variability.

The results of this study should be helpful in answering questions related to organizational arrangements conducive to increasing the income, employment, and general welfare conditions for the rural population of the Sertão of Northeastern Brazil.

Plan of Presentation

The dissertation is presented in six chapters. Following this chapter, Chapter II provides general discussion of previous work on sharecropping and other contractual arrangements. The brief review of the literature provides a background for the present study and an indication of the need for further research in the area of contractual arrangements and their economic implications in agriculture in the developing countries. Risk considerations are discussed and explicitly introduced in the analysis. The mathematical programming models are

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[5]This basic assumption differs from the one used in a recent study of sharecropping farms in the same Region, in the State of Ceará, where the landowner was considered as the only decision-maker and sharecroppers were viewed as one of the alternative sources of labor [Soares, 1977].

presented with emphasis placed on the decision-making process where both landowner and sharecropper maximize their own respective objective function within a set of both common and different constraints. In addition, some features of the data and the sample used in the study are briefly discussed.

Chapter III provides a detailed description of the mathematical programming models used in the analysis. The representative resource situation of the Sertão is discussed in terms of sources and types of data. The assumptions of the analysis are presented and the model structures are related to the programming matrix. A brief presentation of the programming matrix includes the coding procedure for both activities and constraints. Detailed information about the specific constraints, activities, and technical coefficients of the decision models are presented.

Results from empirical applications of the decision models are presented in Chapters IV and V. In Chapter IV, the risks associated with different enterprise combinations are discussed and a set of efficient farm plans are presented and analyzed for different farm sizes. The effects, on the efficient farm plans, of changes in sharecropping conditions, removing cotton as an enterprise, changes in cotton prices, and reductions in the amount of available credit for different farm sizes are discussed in Chapter V. In Chapter VI, the results and major conclusions of the study are summarized.

CHAPTER II
CONCEPTUAL MODEL

The enormous amount of literature on sharecropping has been largely linked to alternative forms of land ownership and leasing conditions and directed to questions of resource allocation and output. In the beginning of the 1960's it was generally accepted that sharecropping systems were conducive to an inefficient pattern of resource allocations, and deviations from optimum resource allocation on farms, to a large extent, were taken to be the result of the prevailing tenure arrangements [Marshall, 1920, in 1953; Schickele, 1941; Heady, 1947; Heady and Kehrberg, 1952; Issawi, 1957; Sen, 1966]. Sharecropping arrangements were viewed as inefficient and only owner farming and leasing on a fixed-rent basis were conducive to efficient use of land. The poor opinion of sharecropping was a result of the belief that these arrangements contained exogenous constraints that were determined largely by custom and tradition. Therefore, no attempt was made to analyze how and to what extent the prevailing lease arrangements might themselves have been influenced and shaped by economic factors [Rao, 1971].

Background Literature

General

A significant exception to the traditional thought was the pioneering attempt by Schultz to explain the preference of farmers in the

United States to lease arrangements rather than owning land [Schultz, 1940]. In another study using several empirical studies as evidence in order to show that there are comparatively few significant inefficiencies in resource allocations in traditional agriculture, Schultz has shown that peasants are "poor but efficient" [Schultz, 1965]. It was only recently that a general equilibrium framework developed by Cheung [1969] was able to show that different contractual arrangements do not necessarily imply different efficiencies of resource use as long as they are themselves parts of private property rights. His important work combined theoretical and empirical analysis to arrive at the conclusion that resource allocation under fixed-rent and sharecropping contracts will be identical: "The choice of contracts is determined by weighing the gains from risk dispersion and the transaction costs associated with different contracts" [Cheung, 1969, p. 71]. However, several points in Cheung's theory of share tenancy may be irrelevant in relation to certain situations in the real world. As a consequence, criticisms and extensions of Cheung's theory of share tenancy have been developed in the literature.

Even though some empirical and theoretical contributions to the literature still line up with the traditional thought [Bardham and Srinivasan, 1971; Bell and Zusman, 1976; Bell, 1977], most recent studies tend to show that sharecropping arrangements are not inefficient [Boxley, 1971; Newberry, 1974; Stiglitz, 1974]. Some authors even argue that sharecropping, when rationally chosen, is more efficient than non-share leasing and results in higher expected levels of farm output than would occur otherwise [Sutinen, 1975].

Role of Sharecropping Tenancy

Sharecropping tenancy is one of the earliest forms of production organization in agriculture. Presently it is still an arrangement of considerable importance in peasant agriculture in many developing countries where capital may not be directly available to many families. Sharecropping is an aspect of the structure of the firm. It is a contractual arrangement with the firm whereby some of the rights of use of the resources in the productive process are transferred to the workers under specified conditions that cover the method and amount of renumeration to the owners. If such payment is based on a share or proportion of the value of output, the resulting agreement is described as a share lease or contract [Sutien, 1975].

Farm lease contracts may be defined as institutional devices for allocating risk among landlords and tenants [Schultz, 1968]. Cash rents guaranteed in advance of production imply that the risks of production are shared entirely by the tenants, while sharecropping rentals distribute such risks among the tenants and the landlords in proportion to their respective shares in output. Fixed kind rents settled in advance of production imply the sharing of price uncertainties but allocate the yield risks entirely to the tenants [Rao, 1971]. Nonagricultural institutions that allow the entrepreneur to shed much of the risk associated with the firm's economic activity also exist. Examples include the commodity futures markets, fire and marine insurance, and the issuance of stock which allows entrepreneurs to avoid some of the risk by permitting outsiders to share in the firm's profits and losses [Arrow, 1971].

A number of recent studies have shown evidence of the importance of risk in decisions made by peasants [Moscardi and de Janvry, 1977; Schulter, 1971; Dillon and Anderson, 1971] and by farmers [Soares, 1977; Lin et al., 1974]. Attitudes toward risk present major problems for rural development programs designed to improve the welfare of low income farmers. There is evidence that risk may be an important barrier against the diffusion of new technologies and, thus, traditional farming methods remain the more attractive alternative [Roumasset, 1976].

Risk Considerations, Received Theory of Contractual Choice, and Their Application to Northeastern Brazil

The Sertão, drought prone sub-region of Northeastern Brazil, is characterized by very low annual precipitation. Another feature of the area is its uneven rainfall distribution throughout the year. The economic and social implications of these severe weather adversities are well known and documented in Brazil [Andrade, 1964; Furtado, 1962]. As a result of the poor environmental conditions, agriculture in the Northeast is extremely risky when compared to other regions of Brazil. In the present study, risk is defined as the probability of actual income deviating from expected income and is measured by the coefficient of variation.[1]

Several studies [O'Mara, 1971; Officer and Halter, 1968], which include estimates of the farmer's utility function, attest to the fact that farmers are not risk neutral. The functions presented in these studies show risk aversion in the relevant range of values of farm incomes. An inevitable consequence of risk aversion is that any

[1]Walker and Nelson [1977] define "risk" in terms of the chances of adverse outcomes associated with an action.

omission of risk considerations in programming models is likely to lead to overestimates of the supply response for farm enterprises that have high variance in yields and/or prices. In addition, since these are often high value enterprises, omission of risk is likely to lead to an overstatement of the returns to investment. These biases may be particularly large in models that involve special contractual arrangements between farmers and low income groups where risk aversion is likely to be greatest.

Well developed methodologies for handling risk at the individual farm level are found in the literature for a wide range of decision criteria [Halter and Dean, 1971]. While the formal analysis of the firm is similar to the formal analysis of the consumer in a number of respects, the differences between them are not quite obvious [Henderson and Quandt, 1971]. A production function is objective, and the output of a firm is easily measured; a utility function is subjective, and utility does not possess an unambiguous cardinal measure. Ultimately, the profit maximization process of a farmer with a given capital constraint and the utility maximization process of a consumer with a given income are decisions made under risk.

Theoretical improvements in economics have led to the concept of maximization of the expected utility as the general choice criterion [Halter and Dean, 1971]. Therefore, the decision maker's preference among risky prospects can be transformed into utility numbers and, thus, a utility function for monetary gains can be derived. If the utility function is known, decision problems can be solved by maximizing expected utility. Hence, expected utility is an index that any decision maker can maximize if he is consistent with his preferences among

risky anticipations. Once the utility function is derived, preferences for risky anticipations of the decision maker in more complex decision problems can be solved by maximizing the expected utility.

In two special cases, maximizing expected monetary value is equivalent to maximizing expected utility. The first case is when the utility function is linear. The second case is referred to as repeated decisions, i.e., decisions in which the opportunity for decision is recursive and the decision maker is financially able to participate repeatedly [Halter and Dean, 1971]. Thus, one extreme is the case in which the decision is made only once and the other is a case in which a decision is repeated continuously.[2]

In conclusion, whether a decision is made once or is made many times, the criterion that is consistent with the decision maker's preference is utility maximization. In addition, when a decision maker's preferences can be represented by a utility function, then he is behaving, i.e., making choices, as if he were a maximizer of expected utility. The next step would be to inquire with regard to the type of utility function the farmer would be expected to have. However, before pursuing this subject, it is necessary to interrelate risk and the theory of contractual choice.

As pointed out by Rao [1971], Cheung's theory of the choice of contracts refers to the "gains from risk dispersion," but omits any consideration of the scope for decision making in the face of uncertainty

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[2]Independent of the risk involved with each action, the decision maker in this limiting case has a preference among monetary outcomes. Therefore, maximizing expected monetary value will provide a choice among actions which is consistent with those preferences. And, based upon the law of large numbers from statistical theory, maximizing expected monetary value in each decision will result in the largest monetary sum over all decisions [Halter and Dean, 1971].

and the nature of the production function, as explained below. This implication suggests that share contracts are expected to be used more often in areas characterized by a high degree of risk than in areas of relative uncertainty, if transaction costs are equal [Cheung, 1969]. Even though this situation may be true for the Sertão Region in Northeastern Brazil, that is, its agriculture is characterized by a high degree of uncertainty and share contracts are widespread, it has been shown through empirical studies that relative economic certainty, in the sense of limited scope for decision making, seems to be necessary for the prevalence of sharecropping. Otherwise, individual anticipations regarding input-output rates and prices may differ, which would make it difficult for the parties concerned to agree upon a choice as to product mix and the amount of inputs to be committed [Rao, 1971]. However, this condition also exists in the Sertão. The environmental conditions of the Sertão are such that no significant scope for entrepreneurship exists; therefore, there may be an incentive for the tenants to reduce the variance of their incomes by shifting part of the uncertainty to the landlords through sharecropping arrangements.

It is well known that, in agriculture, the conditions of production change sharply and important decisions must be made at different intervals and, as a result, large farms may face managerial (supervisory) diseconomies [Robinson, 1962]. Given that indivisibilities are relatively few in agriculture, technical economies to scale may be negligible, especially under labor intensive farming such as that in the Sertão. Since entrepreneurial functions are relatively unimportant in this region, landlords may find it profitable to lease out at least part

of their land on a share-rent basis, rather than to cultivate the entire holding with hired labor.

Another point refers to the absence of any consideration in Cheung's theory regarding the nature of the production functions. In the Sertão, traditional agriculture results in production functions characterized by relatively inflexible input combinations. Therefore, the costs of enforcing tenants' input would be lower and the incentive for share contracts would be greater in comparison with conditions in which there is more flexibility with respect to inputs. It seems that this condition is necessary for areas where sharecropping is extensive and where landlords prefer to lease out land, at least part of it, as a result of managerial diseconomies when the entire land area is cultivated with hired labor.

Finally Cheung's assumption with respect to the aggregate production function fails to recognize the fact that the landowner and the sharecropper may give different weights to producing cash versus subsistence commodities. Given the importance of risk and the uncertainties of producing and marketing agricultural products [Scandizzo, 1974; Holanda and Sanders, 1976; Sanders, 1976], sharecroppers may give higher priority to subsistence commodities than cash commodities. The ranking of objectives, in this case referred to as lexicographic utility, is in conflict with the assumption of an aggregate production function.[3]

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[3]Sanders [1976] emphasizes that studies using production functions to determine optimum input use are based on the assumption of linear utility functions in which the farmer only maximizes income. Even if this assumption about the farmer behavior is accepted, the farmer would not equate the <u>ex-post</u> observed marginal value product to the input price. Instead, he would equate his <u>expected</u> value of the marginal product to the input price. Lipton, <u>cited by</u> Sanders, focuses on this problem in more detail and is concerned with the farmer's utility

This point may also explain why poor farmers prefer traditional technology, given the types of new technology available to them. The decision process concerning the choice of a type of technology is affected by its outcome where the farmer's life, his work, and the survival of his family may be threatened. Even though the expected yields may be quite different, depending on what kind of technology he adopts, their utility can differ in a way that causes them to prefer the traditional technology where output is more certain, when it is assumed that the producer is also a consumer.

Thus, a more adequate model is needed to represent the behavior and the interrelationships between landowners and sharecroppers. Such a model would permit us to explain these poor farmers' decision-making process and to test several hypotheses such as, they do not adopt the new technology made available to them since they wish to avoid the risks which may be incurred by their use.

A related problem, faced mostly by medium and large farmers in the study area, is the seasonal scarcity of temporary labor, especially during peak seasons. There is an indication from previous studies, where sharecropping was a major source of labor, that farmers find it difficult to meet their labor requirements [Sanders and Hollanda, in press].

Another hypothesis which could possibly be tested is one concerned with the supply of agricultural labor. Recently, theories have been developed which attempt to explain the existence of small farms and sharecropper systems as sources of labor supply for the landowners and

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function. He indicates that Indian farmers' behavior seems to be adequately described by a lexographic utility function with a series of cultural constraints [Lipton, 1968].

plantations [Rezende, 1976]. This line of reasoning is based on a historical analysis where, given the seasonal nature of the demand for agricultural labor, it becomes crucial for landowners and plantation systems to have guaranteed access to cheap labor at the time of the year they need it. Therefore, the existence of small farms (minifundios) and sharecropper systems are imperative in order to guarantee a labor supply from the landowner's point of view.

In the study region, a typical share contract includes several components which are negotiated directly between landowners and sharecroppers. All markets can be assumed to be competitive and rights to all property are private. The farm is owned and organized by a landlord who has considerable economic, social, and political power [Johnson, 1971]. But, the landowner cannot unilaterally dictate the terms of the contract since sharecroppers have some economic alternatives. A large number of potential sharecroppers exist and they are assumed to have identical utility functions. Although the contract is verbal, it has real meaning for both the landowner and the sharecropper. The costs of negotiating and enforcing the terms of the contract are negligible, and all other means for transferring the risk inherent in production are extremely costly. A typical contract includes four major components, the crop share, the marketing charge, the size of the plot, and the sujeicão labor.

The sharecropper is allowed to produce enough food crops to supply his family's consumption. In general, the landowner receives 50 percent of the cash crop (cotton) and 30 percent of the food crops. The landowner's facilities are used to market the shares retained by the sharecropper. For these services, the landowner retains 25 percent of

the amount of the cotton marketed through his facilities. The size of the plot given to the sharecropper depends on the labor available from the sharecropper's family. According to data from the farm survey used in this research, the average sharecropper family has 2.2 adult equivalents of labor, or 55 man-days of labor per month, given a 25-day month for an average of 10 hectares.[4]

The fourth major component of the contract is the sujeicão labor, which consists of the obligation of the sharecroppers to provide labor to the landowner for a daily wage that is less than that earned by temporary or permanent workers. The amount of labor provided to the landowner varies from farm to farm, but, on the average, it is equivalent to one man-day per week. In this way the landowner can guarantee a cheap source of labor to work on the owner-operated part of the farm.[5]

Given the traditional nature of the production inputs observed in the Sertão, which frequently involves only labor and land, one would expect fixed proportions and constant returns to scale. Empirical evidence of this relationship for the agriculture of Northeast Brazil is given in a study conducted by Barbosa [1976] where potential benefits and costs related to land reform were estimated for several production functions. Constant returns to scale occurred for all crops with the exception of sugarcane.

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[4]Identical data were used in a recent study conducted by Kutcher and Scandizzo. There is no reason why the data used here should be different, since sharecropper data came from the same sample [Kutcher and Scandizzo, 1976].

[5]For evidence of the fact that incentives exist for landowners to employ sharecroppers in Northeast Brazil, reference is made to a recent study in which the four basic components of the sharecropping contract were parameterized, presented at the 1977 Annual Meeting of the American Agricultural Economics Association [Bettis *et al*., 1977].

Mathematical Programming Model

Two mathematical programming models that incorporate risk were developed. One model represents the landowners and the other represents the sharecroppers. In each model, the respective class member maximizes his own objective function within a set of common and unique personal constraints. Optimal behavior of the sharecropper, within his decision environment, is taken as given in the landowner model.

The basic programming models were designed to serve two main purposes. The first purpose was to simulate and explain existing systems found on farms of different sizes. The second purpose was to simulate how these farms would react to changes in specified policies. An expected income-variance (E-V) utility function is used in each model. That is, both farmer and sharecropper hold preferences among alternative farm plans solely on the basis of their expected income E and associated income variance V. In other words, they are happier, the higher their average (or expected) income and the lower their income variability. Income variance is assumed to be an adequate index of income variability. Iso-utility curves are convex in the E-V plan, i.e., the landowner and the sharecropper are risk averters.

As illustrated in Figure 2, along every iso-utility curve, both landowner and sharecropper would prefer a strategy with higher income variance only if the expected income were greater and this compensation must increase at an increasing rate with increases in the income variance. Given these assumptions, the rational choice among farm plans would be one which has a maximum attainable expected income for a given income variance or one which has a minimum income variance for a given

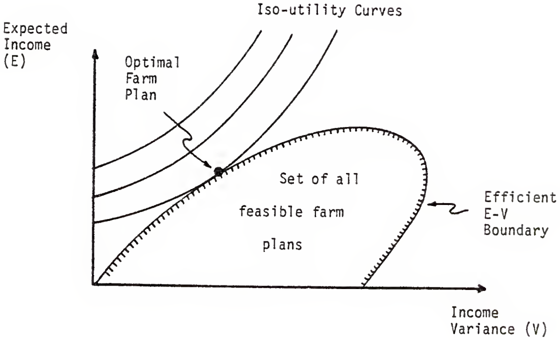

Figure 2. An E-V frontier and iso-utility curves

expected income. These formulations follow concepts developed by Markowitz [1959] and Freund [1956].

Sharecropper Model

The resource allocation problem of sharecroppers was specified as the following quadratic programming problem:

$$\text{to maximize } S'X - \frac{\alpha}{2} X'MX$$

$$\text{subject to } AX \leq b$$

$$X \geq 0 \quad \text{for} \quad S = \begin{bmatrix} C \\ 0 \\ R \\ 0 \\ W \end{bmatrix}; \quad X = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \end{bmatrix}; \text{ and } M = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & Q & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

where,

α = the risk aversion parameter;

C = a vector (5x1) of expected production costs per hectare of land;

0 = a vector (8x1) of zeroes;

R = a vector (8x1) of expected gross revenue per hectare for crops sold;

0 = a vector (5x1) of zeroes;

W = a vector (18x1) of daily wages paid or received by sharecropper;

X_1 = a vector (5x1) of crop production in sharecropper's plot, in hectares;

X_2 = a vector (8x1) of transferred crops from production to selling and/or consumption activities, in kilograms;

X_3 = a vector (8x1) of quantities of crops sold, in hectares, where the market margin and the share to landowner are deducted;

X_4 = a vector (5x1) of crops consumed, in hectares;

X_5 = a vector (18x1) of labor partitioned bimonthly, sold, or purchased by sharecropper, in man/days;

Q = a (8x8) variance-covariance matrix of gross revenue associated with X_3;

A = a (34x44) linear technology matrix with the fixed input-output coefficient a_{ij} as its (ij)th component; and

b = a vector (34x1) whose components represent the resource availability and other technological restrictions.

Landowner Model

The resource allocation problem of the landowner was specified as the following quadratic programming problem:

$$\text{to maximize } S'X - \frac{\alpha}{2} X'MX$$

$$\text{subject to } AX \leq b$$

$$X \geq 0 \quad \text{for} \quad S = \begin{bmatrix} R \\ T \\ C \\ W \end{bmatrix}; \quad X = \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix}; \text{and} \quad M = \begin{bmatrix} Q & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

where,

α = the risk aversion parameter;

R = a vector (9x1) of expected net revenue per hectare or animal-unit for the enterprise from the owner-operated part of the farm;

T = a vector (3x1) of expected net revenue for the owner's share of the sharecropped part of the farm plus forage products for cattle for medium and large farms;

C = a vector (6x1) of capital and land improvement costs per cruzeiro and per hectare of land, respectively;

W = a vector of daily wages paid or received by the landowner, (24x1) for small and (27x1) for medium and large farms;

X_1 = a vector (9x1) of enterprises from the owner-operated part of the farm in hectares or animal units;

X_2 = a vector (3x1) of enterprises from the sharecropped part of the farm plus forage products for cattle for medium and large farms, in hectares;

X_3 = a vector (6x1) of borrowing money and land improvement activities, in cruzeiros and hectares, respectively;

X_4 = a vector of labor partitioned bimonthly, purchased, or sold by the landowner in man/days, (24x1) for small and (27x1) for medium and large farms;

Q = a (9x9) variance-covariance matrix of gross revenue associated with X_1;

A = a linear technology matrix with the fixed input-output coefficient a_{ij} as its (ij)th component, (28x39) for small and (44x45) for medium and large farms;

b = a vector whose components represent the resource availability and other technological restrictions, (28x1) for small and (44x1) for medium and large farms.

Characteristics of the Sample and Data Requirements

The primary data used in this study were taken from a random sample of 8,000 farms surveyed in the Northeast of Brazil by the SUDENE/World Bank project [Scandizzo and Kutcher, 1974]. The survey involved the stratification of 1,500 administration units (municipios) by ecological zone and production orientation, and the stratification of establishments by size. The sample size was determined by exogenous enumeration capacity and was allocated to the various strata according to decision rules based on the variance of key farm variables.

In addition to the sample mentioned above, a sub-sample of sharecroppers on surveyed establishments and secondary data from several Brazilian government sources were used.[6] From the SUDENE/World Bank survey, which covered all nine states of the Northeast,[7] two municipios (Caicó and Florânia) in the State of Rio Grande de Norte were selected as the area for this present study. The following criteria were used in

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[6]Basically, the data from the sub-sample of sharecroppers were used for the sharecropper sub-model.

[7]Maranhão, Piauí, Ceará, Rio Grande de Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia.

the selection:

(a) These municipios were representative of the Semi-Arid Region with respect to ecological and resource endowments;

(b) In the Semi-Arid Region, the farms of the sample were the most homogeneous among themselves with respect to cropping patterns and enterprise combinations;

(c) They were representative of a cotton growing area in which sharecroppers were employed; and

(d) Agricultural production in the year of the survey was considered to be normal.

After careful examination of the questionnaires in the sample, 73 farm owners and 10 sharecroppers[8] were selected.

For the purpose of this study the stratified random sample, conducted by the SUDENE/World Bank project of six farm sizes, was arranged in three new farm sizes, small (< 50 ha), medium (50-199 ha), and large ($\geq$ 200 ha).[9] The data from these questionnaires were used to determine the constraint sets of the programming models (right-hand side). The technical coefficient matrix was constructed by using the budget data given in Appendix B.[10]

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[8]The apparent low number of sharecroppers is due to the extremely homogeneous nature of their cropping patterns, enterprise combination, and resource endowment [Scandizzo and Kutcher, 1974]. These features were confirmed by the author in a field trip to the study area in August 1976.

[9]The original SUDENE/World Bank stratification by farm size was 0-9.9, 10-49.9, 50-99.9, 100-199.9, 200-499.9, and 500 hectares and larger.

[10]The budget data given in Appendix B were obtained in the same survey conducted in the SUDENE/World Bank project; however, they correspond to the whole Semi-Arid Region. The reason for using different approaches is due to the sample design used by the SUDENE/World Bank project, in which two different questionnaires were used--one to obtain resource endowments and the other for technical coefficients. For more details, see the project sampling procedures [Scandizzo and Kutcher, 1974]. In addition, the cattle budgets were obtained by Haroldo Lyra from CEPA-RN (State Commission for Agricultural Planning) and were adjusted with the help of Dr. João Monteiro de Sales Andrade from EMBRAPA, Ministry of Agriculture, who is quite familiar with the study area.

CHAPTER III
METHOD OF ANALYSIS

This chapter includes the discussion of three topics. First, the basic modeling assumptions and a description of the typical situations for the sharecropper and for three typical farms are presented. Second, the model structures are related to the programming matrix. Resource restrictions, economic activities, and coding procedures are presented. Third, the source and construction of the coefficients used in the analysis are discussed.

The structure of the interrelations of the landlord-peasant economy, if not unique, has some peculiarities inherent to the special environmental conditions of the Northeast. Detecting these conditions in order to construct models which represent real-life situations is a difficult task. By definition, models are abstractions from real world situations and, therefore, simplification and abstraction from irrelevant characteristics of reality are as necessary in the application of programming techniques as they are in the use of any other scientific tool. However, the proper simplification and what constitutes irrelevant characteristics are subject to individual judgment and experience.

Model Assumptions

The modeling process is based on linear and quadratic programming techniques. The programming models account for major relationships between sharecroppers and landowners, such as production activities on

owner-operated and sharecropped parts of the farm, sharecropper plot size, production share, market margin, sharecropper labor (sujeicão), and sharecropper consumption. Given the share contract, the typical sharecropper maximizes his income subject to his constraint set. The results are then incorporated into the farm models as activities for further optimization by the landowners. This procedure represents an important attempt to incorporate specific and unique characteristics of the model. A farm-level framework was developed because this approach is able to incorporate the complexities of the individual farming system. The basic model is based on a "core" of activities and constraints which are common to all sub-models. Sub-models were constructed by adding additional rows and columns, or by changing the elements of the rows and columns of the basic tableau. Single-period programming models were developed for a typical sharecropper unit and for three typical farm sizes found in the Sertão do Seridó. The models were specified so that the typical farms have identical production practices for a given level of technology and similar resource constraints, differing only in cattle enterprises and in the quantity of resources available. Among other features, the models allow for owner-operated production, sharecropped production, small farmer and sharecropper's work outside their plots, and sharecropper consumption. It is assumed that landowners and sharecroppers maximize net returns subject to their resource constraints. Input and production markets were assumed to be perfectly competitive and prices and yield expectations were as specified.

Given the nature of the uncertainties faced by the Northeastern farmers and the methodology of this study, risk was explicitly introduced

in the models by the expected income-variance criterion. Quadratic programming was used to maximize expected incomes for given levels of income variance. By the use of a parameterization technique, efficient frontiers were derived where farm decision-makers were allowed to choose a farm plan from different combinations of risk (income-variance) and expected income.

The following material specifies the nature of the resource restrictions, the activities included in the models, and the details of the objective function(s).

Typical Farm Units

Given the environment and the endowment resource conditions of the producing area, only a relatively small number of alternative enterprises are relevant to a typical farm in the Seridó region. This area is characterized by its specialization in cotton and cattle production, where the most frequently observed inputs involve only labor, land, and simple forms of capital. Net farm incomes for a representative sharecropper plot and three farm sizes, consisting of 10, 19, 119, and 441 hectares, were Cr$4,316, Cr$5,849, Cr$10,182, and Cr$20,392, respectively.

The levels of resources available for the year of the programming analyses are shown in Table 3. The typical enterprises include cotton, cattle, and food crops (beans, corn, cassave, and rice). Crops are grown partly by landowners and partly by sharecroppers, while cattle are usually produced only by landowners and are grazed on natural pasture and crop stubble. The average value and herd composition by farm size

Table 3. Initial resources available on the representative farms

Item and unit	Sharecropper plot	Small farm < 50 ha	Medium farm 50-199 ha	Large farm ≥ 200 ha
Land (ha)				
Cropland "A"	---	0.86	1.73	1.07
Cropland "B"	10.0	2.75	16.63	43.13
Pasture	---	7.43	67.51	246.56
Fallow	---	3.22	19.09	101.41
Sharecropper	---	---	10.71	32.43
Other	---	4.55	14.31	49.60
Labor (m/d)				
Family	545.60	217.02	231.00	197.40
Permanent	---	37.50	211.80	185.58
Temporary	90.00	262.50	55.88	880.00
Sujeicão	114.40	---	---	---
Sharecropper	---	---	113.10	342.46
Capital (Cr$)				
Equipment	---	82.23	1,509.55	4,181.33
Structures	---	10,369.10	25,131.74	78,628.94
Working capital	810.80	2,836.14	7,355.04	21,184.92
Borrowing capacity[a]	---	17,795.79	52,017.50	118,508.61
Herd value	---	14,093.88	27,890.38	94,837.80

[a]80 percent of land value.

SOURCE: SUDENE/World Bank Farm Survey.

are given in Table 4. The average herd sizes for small, medium, and large farms are 15, 32, and 100 heads, respectively.

Programming Matrix

The major differences among the models are due to their constraint sets. Other differences are that the sharecroppers are not allowed to produce cattle and that the small farms do not have sharecroppers. In addition, sharecroppers and family labor on small farms are allowed to work outside the farm for daily wages, sharecroppers have consumption requirements, and the technical coefficients of cattle enterprises vary according to farm size. The basic programming matrices used in the analysis are given in Appendix C.

Restrictions

The set of restrictions for the representative farms was derived from the sample data. The restrictions were calculated as an average of the data from the farms in the sample composed of a given size of farm and type-of-farming class. A list of all row codes (constraints) for each basic model is provided in Appendix C.

Land Restrictions

Six types of land restrictions are included in the models: two for cropland on the owner-operated part of the farm (types "A" and "B"), one for the cropland on the sharecropped part of the farm (type "B"), one for pasture land, one for fallow land, and another for sharecropper land balance. Cropland is considered to be that land appropriate for annual cropping, such as cotton, beans, corn, and cassava. Pasture land

Table 4. Average value and herd composition by farm size

Item	Average value per head (Cr$)	Percent of herd composition by farm size		
		< 50 ha	50-199 ha	≥ 200 ha
Bulls	2,316	3.8	2.2	1.8
Wet brood cows	1,872	19.1	20.1	16.0
Dry brood cows	1,356	11.9	13.2	12.1
Yearling heifers/steers	867	20.2	17.4	34.7
Weaned calves	606	24.4	27.4	19.6
Unweaned calves	371	20.6	19.7	15.8
Total		100.0	100.0	100.0

SOURCE: SUDENE/World Bank Farm Survey.

is considered to be that land appropriate for livestock enterprises and particularly cattle, whereas fallow land is considered to be that land not in use either for cropping or pasture. However, the model is flexible enough to permit the transformation of fallow land into pasture and into cropland through capital investments. The sharecropper land balance, which is an accounting equation, allows the models to transfer cropland from the owner-operated part to the sharecropped part of the farm. The total availability of owner-operated cropland, sharecropped part of cropland, pasture, and fallow land was set at the average for each farm size. Because of differences in land quality, cropland was classified into two classes. Type "A" refers to more humid river basin areas, i.e., lowlands or those located on the margins of reserviors and rivers. Type "B," which constitutes the larger part of the cropping land in the study area, is used for cotton, cattle, and sharecropping.

Labor Restrictions

Availability of labor was entered in terms of man-day equivalents and was subdivided on a bimonthly basis to allow for the marked seasonality of labor requirements of crop activities. The set of labor equations was divided into the following categories:

(a) Labor available to the landowner is made up of the amount of all labor available to work on the owner-operated part of the farm. All classes of labor (family, temporary, permanent, etc.) can be transferred or purchased in order to supply labor for the landowner's activities.

(b) Labor available to the sharecropper is made up of the sharecroppers and their family labor that live on the farm. It can be increased by new sharecroppers and/or by temporary labor hired by the sharecroppers. The purpose of this restriction is to make labor available to work on the sharecropper's part of the farm.

(c) Family labor is composed of the members of the operator's family who perform unpaid farm work. This type of labor was made available to work on the owner-operated part of the farm by transfer activities. A deduction was made for the number of days the members of the family work off-farm and/or attend school, especially for the children.

(d) Sharecropper labor is made up of the requirement stipulated in the sharecropping contract, where the sharecropper is obligated to work one day weekly for a daily wage somewhat less than that earned by a temporary or permanent laborer (sujeicão labor). This constraint can increase as the sharecropping area of the farm increases.

(e) Temporary labor constraint is a limitation imposed on hiring temporary labor in period 2, one of the peak seasons. It was calculated as an average of the sample data.

Consumption Restrictions

In the sharecropper's model, four consumption level constraints were set for food crops. These restrictions are consistent with the typical share contract which allows the sharecropper to produce enough food crops to supply his family's consumption. The sharecropper family's consumption of basic foodstuffs is met by a fixed minimum amount of beans, corn, rice, and cassava necessary for the family's year-round subsistence.

Capital Restrictions

Given the multiple uses of financial capital and interest rates paid by the farmers, capital restrictions are expressed in a set of five equations:

(a) Operating capital borrowing constraint sets a limit of Cr$15,600 for borrowing money at special low interest rates for specific working capital purposes.

(b) Investment capital borrowing constraint sets a limit of Cr$15,600 for borrowing money at special low interest rates for specific investment capital purposes.

(c) Borrowing capacity was determined on the basis of the land value of the farm. The borrowing capacity was assumed to be 80 percent of the value of farm assets. This limit is set by local branches of the Banco do Brasil, which is the most important institutional lender in the region. Beyond this amount, there is no discretion in lending, and application for credit must be forwarded to the central agency.

(d) Available operating capital was set up for borrowing money for working capital purposes above the Cr$15,600 limit. This special restriction is needed because above this limit the interest rate is higher.

(e) Available investment capital was set up for borrowing money for investment purposes above the Cr$15,600 limit. This restriction is needed because above this limit the interest rate is higher.

Two major reasons are responsible for the specification of capital restrictions in this fashion. No data were available from the survey for owned financial resources and, according to information from local extension agents, most local financial resources came from bank loans. In addition, this approach has been suggested to overcome the lack of data on owned financial resources and has been used in several programming studies in Brazil [Sarmento, 1975; Patrick, 1974; Panagides et al., 1973].

Accounting Equations

In addition to the restrictions described above, three groups of accounting equations, two groups for the sharecropper's model and one group for the landowner's model, were specified. The first group of sharecropper equations is the total product balance, which permits the sharecropper's model to handle separately the production and selling activities. There is one of these equations for each different product considered in the sharecropper's model. The justification for this is the prevailing sharecropping system, where the landowner's share and

market margins are discounted from the sharecropper's objective function, and the convenience of separating products from mixed-cropping activities in the selling process. These accounting equations can handle these products so that they can be sold independently.

The second group of sharecropper equations handles the commodity balance, which enables the models to distribute each product among the selling and consumption activities. In addition, through several transfer activities, these equations permit production on the sharecropped part of the farm to be split between the landowner and sharecropper according to the stipulated shares of the contract.

Finally, the third group of equations, related to the landowner's model, is the forage balance which accounts for the availability of forage as an intermediate product for cattle.

Activities

The activities included in the models may be divided into three major groups: (a) production activities, (b) buying and selling activities, and (c) transfers. Group (b) may be subdivided into production related, labor related, and capital related activities, and group (c) activities may be subdivided into production related and land related activities.

Appendix C provides a list of all column activities for the sharecropper and the landowner, respectively.

Production Activities

Production activities included in the models are limited to those already existing on the farms and account for both final and

intermediate products. It may be argued that limiting the production activities to those currently found in the production area rules out potentially important sources of expanded income and employment opportunities. However, given local environmental conditions, the introduction of new enterprises into the region would involve considerable investments in agronomic research and extension services. In addition, the development of an appropriate marketing infrastructure and appropriate managerial skills would also be required. Therefore, the development of appropriate production coefficients and the specification of the necessary restrictions in order to simulate these conditions would require an extensive research effort in itself. Given these reasons, the scope of this present research is limited to the existing production activities.

Perennial cotton is the most important crop included in the models. Other crops included are rice, beans, corn, and cassava. Cattle, an important complementary enterprise, is also included together with its intermediate products such as palma and elephant grass.[1]

Some other crops such as sweet potatoes, sisal, and bananas were found in such limited areas and on such a small number of farms, that they were considered negligible and not included in the analysis.

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[1]Palma, Opuntia sp., is a cactus, native to the Semi-Arid Northeastern Brazil, used for forage. It has the shape of the palm of the hand and is well known for its high water-holding capacity (it contains 90 percent water). Elephant grass, also known as napiergrass, Pennisetum purpureum Schumach, introduced from South Africa, is a robust, erect, leafy, tufted, branching perennial 2-4 m tall with elongated blades 2-3 cm wide and has a dense, tawny inflorescence. It grows into clumps and tilers abundantly [Rotar and Plucknett, 1975].

Buying and Selling Activities

Production related

Production and sales activities of crops are handled separately in the sharecropper's model. This procedure is followed because of the interplanting system plus the necessity of separating the shares of production that accrue to the landowner from those that accrue to the sharecropper. Hence, the different commodities produced are separated through corresponding transfer activities that generate specific selling activities for each commodity.

Labor related

A set of six activities is included in this group: (a) family labor, (b) temporary labor, (c) sharecropper labor, (d) permanent labor, (e) off-farm work, and (f) number of sharecroppers. These activities are disaggregated into these categories in order to incorporate the wage differentials that exist among the different types of labor and to indicate the levels of use by category. The bimonthly partition of the first five categories of labor was made so that seasonal aspects of labor demand could be introduced into the analysis.

The labor activities were specified so that a predetermined sequence for them to enter the solutions could be met. Family labor is used first. This was achieved by the zero cost at which family labor entered the solutions. Second, if profitable, sharecropper labor (<u>sujeicão</u>) would be used, since it is already available on the farm and could be increased at low costs. In addition, the landowner increases his income through his share in the production of the sharecropped part

of the farm. This activity was accounted for by a daily cost of Cr$4.00 stipulated by the share contract and paid by the landowner. Third, hired permanent labor would come into the solution at the going wage rate of Cr$6.00 plus housing and other small privileges. These activities were restricted to the total amount available on the farm. Fourth, hired temporary labor would come into the solution at the going wage rate of Cr$7.00. Fifth, sharecroppers and small farm family labor are allowed to work outside the farm for the market wage of Cr$6.00. This group of labor related activities, also partitioned bimonthly, may supplement the sharecropper and small farmer's income. Finally, sixth, there is the number of sharecroppers activity which allows variation in the number of sharecroppers on the farm. As the landowner makes new share contracts, more sharecropper labor will be available to work on the owner-operated part of the farm.

Capital related

There are four capital related activities. Two different activities are considered for operating capital and two others for investment capital. Table 5 shows the different types of loans available. According to the sample data, 40 percent of the loans were for investment purposes and the Banco do Brasil is responsible for 95 percent of all institutional loans in the study area.

Transfer Activities

The number of production related transfer activities in the sharecropper's model equals the number of commodities produced by the production activities. These production transfer activities enable the

Table 5. Annual interest rates for different types of loans, Seridó, RN, 1973

Type of loan	Market interest rate per semester	Loan payment period	Grace period
	(percent)	(months)	(months)
Operating expenses up to Cr$15,600	5.0	12	--
Operating expenses over Cr$15,600	7.5	12	--
Capital investment up to Cr$15,600	5.0	96	36
Capital investment over Cr$15,600	7.5	96	36

SOURCE: Banco do Brasil S.A. and SUDENE/World Bank Farm Survey.

model to transfer each individual product from the production activities and distribute them between the selling and consumption activities.

The land related transfer activities may be characterized in three types. The first, improved fallow land, transforms fallow land into pasture. The second, improved pasture, transforms pasture into cropping land type "B". The third, sharecropping land supply, permits the landowner to provide cropping land to new sharecroppers.

Technical Coefficients, Costs, and Returns

The technical coefficients, costs, and returns which describe each linear production function associated with each production activity were developed from the budgets provided in Appendix B.

The main source of the data used in the construction of these coefficients was the farm survey [SUDENE, 1976]. Nevertheless, other data from several publications, such as those from SUDENE, Banco do Brasil S.A., and State Commission for Agricultural Planning--RN, also were used to adjust and complement the data in developing the budgets given in Appendix B. The SUPLAN/BNB Farm Survey, conducted in 1971/1972, also permitted additional improvements in the coefficients [SUPLAN, 1973]. The technical coefficients, costs, and revenues represent means derived from the farm survey and, in some cases, adjusted by the use of information obtained from the other sources listed above.

Variance-Covariance Matrix

Ideally, the variances and covariances of the unit level net revenues should measure the variabilities in the net revenue of these

processes under conditions of constant price levels and constant managerial practices [Freund, 1956]. However, since such data are not available for the type of farms which are being analyzed in Northeastern Brazil, approximation procedures were used to obtain estimates of the elements of the Q matrix. It was assumed that only prices and yields of the outputs are random variates. Prices of all inputs, such as seeds, pesticides, and insecticides, were assumed fixed at given levels. If this assumption is not correct, it would have little effect on the results, in view of the very limited quantity of purchased inputs. Prices used to obtain estimates of the past unit level gross revenues consisted of adjusted state averages deflated by a general domestic price index. The yields used consisted of adjusted averages for the sampled region. These past unit revenue estimates were used to obtain the variance-covariance Q matrix.

The estimation of the risk aversion constant is a purely subjective task, and any chosen value is exceedingly difficult to defend [Freund, 1956].

CHAPTER IV
EMPIRICAL ANALYSIS

The results obtained when the decision models were applied to the initial farm conditions prevailing in the Seridó Region of Northeastern Brazil are presented in this chapter. In the first section, results of the analyses of the relative riskiness associated with each individual farm enterprise are presented. In the second section, the procedure used to develop the efficiency frontiers is discussed. The third section reports the analyses of the efficient sharecropping plans. The next three sections show the farm plans for three different representative farm sizes (small, medium, and large) when risk is minimized for given levels of income. Finally, the results of all the analyses are summarized in the last section.

Enterprise Analysis

A common agronomic practice in the semi-arid cotton-growing areas of Northeast Brazil is the system of intercropping or mixed-cropping. This particular practice is considered to be a means of saving labor and a way in which farmers attempt to minimize the impact of variations in rainfall distribution as some crops are more drought resistant than others. Thus, it is common to observe corn and beans interplanted with cotton, and beans interplanted with cotton and corn. The three major types of cotton are Mocó, Verdão, and Herbáceo. The predominant type found, not only in Rio Grande do Norte but in the entire Northeast, is

moco´ cotton. Highly valued because of its long stable length, which guarantees a higher price in the international market, this perennial tree cotton with an economic life of about five years is more resistant to drought then any other crop [SUPLAN, 1973]. The decision to grow perennial tree cotton (moco´) together with annual beans and corn, for example, reduces the danger of total crop failure; in the event of a drought, cotton would likely yield some revenue. Single crops are usually planted in addition to mixed crops. However, since most of the single crops, such as rice and beans, are grown in the low humid lands (land type "A"), they do not compete with cotton interplanting activities for land. This kind of information plays an important role in the following enterprise risk analysis.

The relative riskiness of the enterprises included in the models was analyzed by comparing the relative magnitude of the standard deviation with the mean of the distribution of gross revenues. The coefficient of variation was used for comparison of the two distributions of gross returns with different means [Kendall and Stuart, 1958]:

$$cv = \frac{s_i}{\bar{x}_i},$$

where,

cv = coefficient of variation,

s_i = standard deviation of gross returns for enterprise i, and

$\bar{x}_i$ = expected gross return for enterprise i.

Table 6 shows the coefficient of variation of gross returns calculated for each enterprise listed in Tables D-5 and D-6. A comparison of the coefficients indicates that the mixed cropping activities involving cotton are less risky than other crop activities. As expected,

Table 6. Expected gross return per hectare, standard deviation, and coefficient of variation of gross return and average labor productivity, by enterprise

Enterprise	Land type	Gross returns			Average labor productivity[a] (Cr$)
		Expected per hectare (Cr$)	Standard deviation	Coefficient of variation	
Single crop					
Cotton	"B"	352	142	.405	12.60
Rice	"A"	676	256	.378	5.25
Beans	"A"	897	419	.467	17.01
Corn	"B"	282	158	.559	5.15
Cassava	"B"	775	573	.739	11.95
Mixed crops					
Cotton/beans/corn	"B"	1,050	332	.316	18.23
Beans/corn	"A"	661	298	.450	9.73
Cotton/beans	"B"	871	241	.277	16.50
Cattle 1[b]	---	382	71	.187	189.14
Cattle 2	---	562	107	.191	265.14
Cattle 3	---	621	120	.193	307.52

[a]Average labor productivity is defined as enterprise expected gross return per hectare divided by total man/days per hectare or per animal-unit.

[b]Per animal-unit rather than per hectare.

crops such as rice, beans, corn, and cassava, which require more water and are less drought resistant than cotton, show higher coefficients of variation than cotton/beans/corn (.316) and cotton/beans (.277).

The low coefficients of variation for cattle enterprises were expected and are consistent with findings of a study conducted in Quixadá, state of Ceará, where the agricultural environment is similar [Soares, 1977]. Cattle production in the region has been rather stable over the years, regardless of its level of technology and losses in dry years. In dry years, in order to avoid heavy losses, landowners may either sell their cattle or purchase the necessary feed for the cattle to survive by means of financial assistance. Another possible factor that may tend to reduce estimated variations in income is the type of data used to calculate the cattle enterprise coefficients. The time series data on gross returns for these activities, similar to the study in Quixadá, were generated from variations over time in the price per kilogram of cattle and from variations in the value of milk production for the state of Rio Grande do Norte.[1] It is expected that the use of these data would produce less variation than that which would occur in individual farms. No reliable data were available that could be used to reflect other changes in productivity over time.[2] However, there appears to have been no significant changes in technology over the years and, according to several extension agents contacted by the author, the

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[1]In the study conducted by Soares, the time series data on gross returns for this activity (there was only one cattle activity) were generated from variations over time in the price per head of cattle and from variations in the quantity and value of milk production [Soares, 1977].

[2]See Appendix D.

farm size is more important than any other factor in reflecting differences in technology over time.

The mixed crops generally have lower coefficients of variation than single crops. One exception is beans/corn (.450), for which the coefficient of variation is higher than for cotton (.405) and for rice (.378). The coefficient of variation for cotton is lower than that of beans/corn because beans and corn require more water and, therefore, are less drought resistant than cotton. In addition, this activity does not compete with cotton for land. According to the sample data, beans/corn, rice, and beans are usually planted in low lands (baixios) or on the margins of reserviors and rivers (vazantes), land type "A." Also, in a drought year it is common to observe these crops being cultivated on empty riverbeds and empty reserviors (acudes) or on their half-empty margins. This practice can partially offset the usual decline of yields during a drought year. The low coefficient of variation for rice, as compared to the beans/corn coefficient, may be due to aggregation bias in the regional yields, since aggregation tends to reduce the estimated variance of gross returns below that actually faced by individual farmers.

It appears that risk averse farmers would select enterprises such as cotton/beans/corn, cotton/beans, and cattle and would not choose enterprises such as cassava, corn, beans, and beans/corn. However, it is not sufficient to analyze risk associated with each individual activity solely on the basis of the coefficient of variation. Even though a specific activity may be considered less risky on the basis of its low coefficient of variation, it may also be one in which resource productivity is low. Table 6 also provides the average labor

productivity by specific enterprise. It can be observed that, although gross returns for rice have a relatively low coefficient of variation, the average returns to labor are low also. Thus, large amounts of a relatively low risk enterprise such as rice may be unsuitable if the minimum level of required farm income is high. In addition, the covariances among the enterprises are very important in the process of selecting one particular enterprise combination versus another. If two specific enterprises are uncorrelated, a combination of both has a lower variance than if they are positively correlated. It has been shown that the variance-reducing effect of diversification between uncorrelated activities can be strong [Anderson et al., 1977]. For example, the variance-covariance matrix for the sharecropper sub-model shows negative covariances between isolated cotton and mixed cropping beans (Table 7). The variance-covariance matrix for the landowner models presents a negative covariance among isolated corn and cattle enterprises and among isolated cassava and all mixed crops (Table 8). The variance-covariance matrices for both sharecropper and landowner models show negative covariances between isolated cotton and beans and between corn and cotton. The quadratic programming analysis reported in the following sections shows that portfolio combinations among these enterprises yield lower variances (risks) than do individual enterprises to the farmer.

Procedure Used to Develop Efficiency Frontiers

Quadratic programming models described in Chapter II were used to derive four initial efficiency frontiers that represent minimum risk farm plans for each level of expected total returns less variable costs, referred to as expected income. Three different initial efficiency

Table 7. Unit level variance-covariance matrix of gross returns for selected enterprise for the sharecropper sub-model, study area

Crop	Cotton	Cotton 1	Cotton 3	Beans 1	Beans 3	Corn	Corn 1	Cassava
Cotton	20,255.7	9,699.3	11,411.2	-5,907.6	-6,599.3	-4,961.5	-1,294.3	46,397.5
Cotton 1		6,993.9	8,334.9	2,456.2	2,368.4	-176.1	1,580.2	20,539.5
Cotton 3			10,008.1	2,675.6	2,555.4	300.6	2,005.0	25,686.6
Beans 1				38,580.2	40,727.3	19,939.7	19,530.1	-51,960.0
Beans 3					43,004.6	21,091.3	20,607.9	-55,827.2
Corn						24,856.5	19,509.7	-30,997.8
Corn 1							17,198.9	-27,522.4
Cassava								328,072.0

Table 8. Unit level variance-covariance matrix of gross returns for selected enterprises for landowner models, study area

Crop	Cotton	Rice	Beans	Cron	Cassava	Cotton/Beans/Corn	Beans/Corn	Cotton/Beans	Cattle 1	Cattle 2	Cattle 3
Cotton	20,255.7	9,407.5	-12,162.3	-4,961.5	46,397.5	2,517.3	-9,806.5	4,811.9	7,067.0	10,611.5	11,824.4
Rice		65,533.5	82,272.1	19,914.0	3,498.8	52,413.4	56,046.8	36,677.1	10,380.5	15,687.7	17,525.9
Beans			175,324.0	41,058.6	11,750.7	83,439.4	118,459.0	56,972.5	6,882.4	10,146.7	11,223.0
Corn				24,856.5	-30,997.8	39,273.4	39,142.7	21,421.9	-1,536.0	-2,319.3	-2,593.1
Cassava					328,072.0	-58,942.8	-17,288.7	-30,140.6	20,609.8	30,233.4	33,371.5
Cotton/Beans/Corn						109,906.0	71,083.7	76,719.1	391.9	736.5	896.7
Beans/Corn							88,566.6	44,503.6	2,293.0	3,339.2	3,674.5
Cotton/Beans								58,123.6	1,468.5	2,320.6	2,637.3
Cattle 1									5,091.2	7,664.2	8,549.0
Cattle 2										11,542.3	12,876.8
Cattle 3											14,366.6

frontiers were derived for the three different farm sizes (small, medium, and large). Prior to the development of these three efficiency frontiers, an initial sharecropper efficiency frontier was derived so that its results could be used in the generation of the efficiency frontiers for the medium and large farms.

The scalar α ("risk aversion parameter"), as specified in the models described in Chapter II, indicates the decision-maker's aversion to risk; the larger the value of α, the more conservative is the decision-maker. Because of the role played by the risk aversion parameter as the adjuster of optimum farm programs, it may be used as a relative measure of risk over the entire range of the efficiency frontier [Takayama and Batterham, 1972]. Also, since the coefficient of variation is an explicit function of the standard deviation and expected gross returns, it can be interpreted as a relative measure of risk among different efficiency frontiers.

During a field visit to the study area, after the data were collected, the author became aware of an important development taking place in the landowner-sharecropper relationship that was not reflected in the sample data. The newly developed local rural unions, representing agricultural labor interests, have been taking to court most sharecroppers' claims against landowners for unfair dismissal of sharecroppers. According to several landowners and extension agents interviewed by the author, the majority of these disputes were won by sharecroppers and, after an appraisal made by the courts, the landowner was often obligated to compensate the sharecroppers for their cotton fields and housing improvements. As a consequence, most landowners have fewer sharecroppers than otherwise would have been desired on their farms. An attempt has

been made to incorporate this situation in the modeling process, even though no exact data were available. To reflect this indirect cost in the sharecropping activities, the annual gross margins of cotton for a five-year cycle for the 10 hectare sharecropper plot were taken into consideration. In addition, this estimation was made by considering only the sharecroppers' annual share of cotton from the mixed-cropping cotton/beans/corn activity. Since not all sharecroppers were dismissed and no data were available to determine the age of their cotton fields during the appraisal, only one year of gross margins was considered. Therefore, a total of Cr$1,298 was estimated as the average compensation cost for each new sharecropping plot of 10 hectares considered in the models (see budgets in Appendix B). Fences, housing improvements, and other ameliorations were omitted.

The farm plans represented by the frontier were arranged in order of increasing profitability as measured by expected income. The total amount of expected farm income was derived from enterprise expected gross margins. Therefore, the term expected income is used to indicate expected results for an average year rather than the actual level of income for a particular year. The quadratic programming code used was the Rand QP360 [Takayama and Batterham, 1972].

Sharecropper Efficiency Frontier[3]

The initial sharecropper efficiency frontier, also referred to as the sharecropper basic sub-model frontier, is assumed to represent the

[3] In the terminology of Markowitz, proportionate combinations of enterprises that minimize income variance for given levels of expected income are called "efficient portfolios" [Markowitz, 1959]. The collection of all these points for a situation is called an "efficiency locus" or an "efficiency frontier" [Johnson, 1967].

actual situation faced by a representative sharecropper in the study region.

Table 9 presents the variance, standard deviation, coefficients of variation, and plot plans for solution points on the basic sub-model frontier. A relative measurement of risk is provided by comparing the coefficients of variation of the different solutions. Higher coefficients indicate greater risk per cruzeiro of expected income. The values start at zero and reach a maximum of .582 for the linear programming solution at the maximum level of expected attainable income of Cr$4,514. Cotton/beans/corn replaces cotton as the levels of income and risk increase. As the expected income increases so does the level of risk.

A comparison among the survey data and basic sub-model results reveals that solutions corresponding to levels of expected income ranging from Cr$4,171 to Cr$4,514, with the coefficient of variation ranging from .298 to .582, appear to be most similar to the sharecroppers' actual farm plan. Indeed, a solution closer to an expected income of Cr$4,514, which is the linear programming solution, seems to be most similar to the sharecroppers' actual choice. These results indicate that the sharecropper is a risk taker. However, the sharecropper is obligated to cultivate his entire plot by his sharecropping contract which leaves him less time to work outside his plot for wages.[4]

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[4]The sharecropper basic sub-model was also run so that the sharecropper was not obligated to cultivate his entire plot. The solutions for this other specification show that only after the seventh efficient frontier plan (two before the LP solution) would cropland be brought completely into the farm plan. Up to this efficient frontier plan the sharecropper would prefer to sell out his labor rather than to cultivate his entire plot.

Table 9. Variance, standard deviation, coefficient of variation, and minimum risk plans for sharecropper, by expected income level

Item and unit	Quadratic programming solutions								LP solution	Actual plan
	1	2	3	4	5	6	7	8	9	10
Expected income (Cr$)	2,362	2,436	2,670	2,700	2,708	4,054	4,102	4,171	4,514	4,316
Variance (Cr$)	1	1,781	31,642	38,479	40,421	1,282,595	1,359,695	1,548,741	6,906,280	---
Standard deviation (Cr$)	1	42	178	196	201	1,132	1,166	1,244	2,628	---
Coefficient of variation	0	.017	.067	.072	.074	.279	.284	.298	.582	---
Cropping pattern										
Cotton (ha)	8.416	8.413	8.399	8.397	8.387	6.424	6.349	6.227	0	---
Corn (ha)	---	---	---	---	---	---	---	---	---	---
Cassava (ha)	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145	0.145
Cotton/beans/corn (ha)	0.226	0.295	0.720	0.680	0.679	0.952	0.981	3.628	9.855	9.106
Cotton/beans (ha)	1.213	1.146	0.736	0.680	0.679	0.952	0.981	---	---	---
Hired labor (m/d)	227.97	227.98	228.01	228.01	228.01	227.30	227.27	227.31	225.14	190.00
Outside farm work (m/d)	452.26	451.88	449.50	449.18	448.89	391.19	389.07	380.77	193.66	n.a.[a]

[a] n.a. = data not available.

As a consequence of the increase in the marginal risk, the choice of enterprises is increasingly restricted to those which produce the necessary level of expected income. As a result, this reduces opportunities for diversification into enterprises with negatively related covariances and results in greater marginal and total risk. To compensate and to provide more security to the sharecropper and his family, special relations and ties arise between sharecroppers and the landowner. These vertical ties satisfy essential needs, such as the loan of relatively large amounts of cash or goods, medical aid, and general protection of unpredictable or catastrophic circumstances [Johnson, 1971]. These special paternalistic relations, which cannot be quantified and, therefore, could not be included in the modeling process, play a major role in the security of the sharecroppers.

An important observation regarding the sharecropper basic sub-model is that, except for isolated corn which never enters the frontier plan, all activities enter the optimal solutions for at least a limited range of expected income (see Table 9). The reason why isolated corn does not enter the solution is in part due to the low average labor productivity of corn compared with other sharecropping activities. The inclusion of family consumption constraints to the sub-model was believed to be a way to assure that the basic sub-model results approximate sharecroppers' actual crop mix. One of the major features of the sharecropping system, at least from the sharecropper's point of view, is his family consumption needs as indicated by the farm survey.

Figure 3 depicts the sharecropper basic sub-model frontier. The slope of the efficiency frontier decreases as expected income increases, which implies an increase in risk per cruzeiro of additional income.

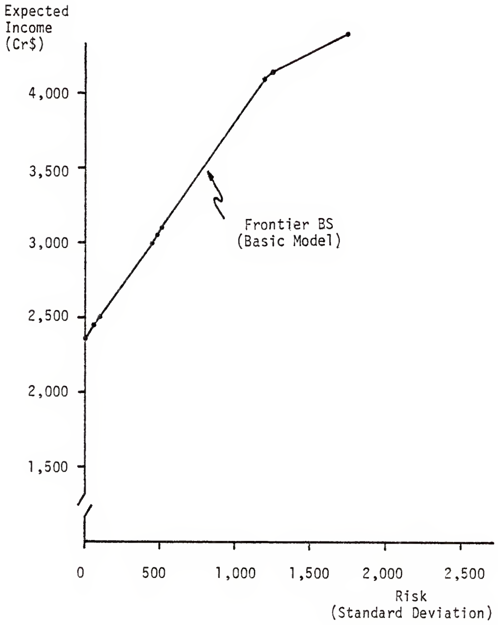

Figure 3. Sharecropper plot efficiency frontier for minimum risk farm plans

Table 10 shows the representative pattern of resource use for a typical sharecropper plot based on the survey data and for two selected frontier plans. With respect to the resource use, there are also significant similarities between frontier solutions and the actual plan. This result was expected since the resources available to the sharecroppers are very limited.

Cropland and operating capital, which is in general equally divided between the landowner and sharecropper, are the major restrictive resources in the sharecropper sub-model. Normally, the landowner furnishes the sharecropper's part of operating capital in advance which is paid back after harvest. As expected, in the programming frontier plans, operating capital is always exhausted in all efficient frontier plans. Family labor is divided between work on the plot and outside farm work. No accurate comparison could be made of outside farm work between the actual plans and programming frontier plans since the sample data were incomplete for this item.

Small Farm Efficiency Frontier

The initial small farm efficiency frontier, also referred to as small farm basic model frontier, is assumed to represent the actual situation of a typical small farm in the study area. Major features of this model, in contrast to the sharecropper model, are that it is an owner-operated farm in which cattle production may be included in addition to normal crops cultivated in the area. However, because of its size, it does not use sharecroppers. The model allows family labor to work outside the farm as a source of income. Table 11 presents the variance, standard deviation, coefficients of variation, and farm plans

Table 10. Expected income, resource use, and production for actual and programmed plans on sharecropper plot

Item	Unit	Actual plan	Programming frontier plans	
Expected income	Cr$	4,316.00	4,171.00	4,514.00
Resource use				
Cropland	ha	10.00	10.00	10.00
Family labor	m/d	545.60	164.83	351.93
Hired temporary labor	m/d	190.00	227.31	225.13
Outside farm work	m/d	n.a.[a]	380.77	193.67
Sujeicão work	m/d	114.40	114.40	114.40
Operating capital	Cr$	810.80	810.80	810.80
Production				
Cotton	kg	1,677.00	1,822.20	1,545.54
Beans	kg	1,080.00	452.94	1,230.38
Corn	kg	1,641.42	1,015.35	2,759.46
Cassava	kg	500.00	578.45	578.45

[a]n.a. = data not available.

Table 11. Variance, standard deviation, coefficient of variation, and minimum risk farm plans for the small farm, by expected income level

Item and unit	Quadratic programming solutions										
	1	2	3	4	5	6	7	8	9	10	11
Expected income (Cr$)	1,303	2,750	2,785	2,893	2,930	3,022	3,183	3,324	3,601	5,050	5,098
Variance (Cr$)	0	87,450	91,726	105,801	110,934	124,192	149,603	174,832	232,321	696,926	717,751
Standard deviation (Cr$)	0	296	303	325	333	352	387	418	482	835	847
Coefficient of variation	---	.108	.109	.112	.114	.117	.122	.126	.134	.165	.166
Cropping pattern											
Cotton (ha)	0	0.11	0.10	0.11	0.11	0.12	0.14	0.11	0.14	0.28	0.44
Rice (ha)	0	0.76	0.76	0.81	0.81	0.86	0.86	0.86	0.86	0.86	0.86
Cotton/beans/corn (ha)	0	0.01	0.01	0.01	0.01	0.01	0.04	0.05	0.10	0.31	0.34
Cotton/beans (ha)	---	---	---	---	---	---	---	---	---	0.14	0.16
Cattle (a-u)	0.002	2.36	2.49	2.67	2.80	2.97	3.50	4.04	4.99	9.91	9.91

Table 11. Continued

Item and unit	Quadratic programming solutions								
	12	13	14	15	16	17	18	19	20
Expected income (Cr$)	5,104	5,482	5,594	5,740	5,741	5,742	5,755	5,849	5,852
Variance (Cr$)	720,230	935,568	1,013,933	1,121,160	1,122,239	1,123,099	1,133,299	1,209,123	1,211,657
Standard deviation (Cr$)	849	967	1,007	1,059	1,059	1,060	1,064	1,100	1,101
Coefficient of variation	.166	.176	.180	.184	.184	.184	.185	.188	.188
Cropping pattern									
Cotton (ha)	0.47	1.68	1.76	1.72	1.72	1.72	1.73	1.71	1.71
Rice (ha)	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Cotton/beans/corn (ha)	0.34	0.56	0.60	0.63	0.65	0.65	0.65	0.67	0.70
Cotton/beans (ha)	0.16	0.37	0.39	0.39	0.38	0.38	0.37	0.37	0.34
Cattle (a-u)	9.91	9.91	10.36	11.16	11.16	11.17	11.24	11.78	11.78

Table 11. Continued

Item and unit	Quadratic programming solutions							LP solution	Actual plan
	21	22	23	24	25	26	27	28	29
Expected income (Cr$)	5,930	5,931	6,129	6,131	6,245	6,276	6,388	6,403	5,521
Variance (Cr$)	1,280,950	1,281,883	1,472,872	1,475,050	1,596,049	1,638,499	2,068,214	2,172,251	---
Standard deviation (Cr$)	1,132	1,132	1,214	1,214	1,263	1,280	1,438	1,474	---
Coefficient of variation	.191	.191	.198	.198	.202	.204	.225	.230	---
Cropping pattern									
Cotton (ha)	1.69	1.69	1.63	1.63	1.60	1.58	0.20	---	1.72
Rice (ha)	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.75
Cotton/beans/corn (ha)	0.73	0.74	0.80	0.82	0.85	1.17	2.55	2.75	1.92
Cotton/beans (ha)	0.33	0.33	0.32	0.30	0.30	---	---	---	0.53
Cattle (a-u)	12.25	12.25	13.47	13.47	14.20	14.20	14.20	14.20	9.93

for solution points on the small farm basic model frontier. The expected incomes of the farm plans in this table range from Cr$1,303 to Cr$6,403 and their coefficients of variation range from zero to .230. In general, cotton and cattle increase and off-farm work decreases as the levels of income and risk increase.

A comparison of the actual plan (last column of Table 11) with the basic model results shows that solutions corresponding to levels of expected income that range from Cr$5,482 to Cr$5,594, with coefficients of variation that range from .176 to .180, appear to be similar to the farmers' actual choice. The cropping pattern of these two solutions, including cotton, rice, cotton/beans/corn, cotton/beans, and cattle enterprises, also correspond closely to the actual plan. Except for cotton/beans/corn, which enters the solution at only one-third of the actual plan, all enterprise combinations are reasonably well represented in frontier solutions between Cr$5,482 and Cr$5,594. The covariance (see Table 8) between rice and cotton/beans/corn is highly positive, which means that the risk of producing both of them is highly correlated. However, the covariance between isolated cotton and beans/corn is negative which implies complementarity; that is, if gross returns for one is high in a given year, then the gross returns for the other is low.

An important observation regarding the small basic model frontier is that, except for isolated beans, corn, cassava, and mixed cropping beans/corn, which never enter the solution, all other activities enter the optimum solutions for at least a limited range of expected income. The reason why isolated corn and mixed-cropping beans/corn do not enter the solutions is in part due to the low average labor productivity associated with these enterprises when compared to the average labor

productivity associated with other activities (see Table 6). While isolated cassava has a very high coefficient of variation (.739), the coefficient of variation of beans (.467), which competes for the same land as rice, is higher than the coefficient of variation of rice (.378).

Figure 4 shows the landowner basic small farm frontier. Each point on the curve represents a minimum risk farm plan to the small landowner for the corresponding level of expected income.

Table 12 presents the resource use for selected farm plans in the initial basic small farm model. The selected farm plans in Table 12 are arranged in order of increasing profitability, as measured by expected income, where the first and the LP solutions are presented in columns 1 and 12, respectively. There are also similarities between frontier solutions and the actual pattern of resource use, especially within the Cr$5,482 to Cr$5,594 income range. The average amount of cropland "A", cropland "B", pasture, fallow land, and family, permanent, and off-farm labor constitute the right-hand-sides of the small farm programming model. These constraints account for some of the similarities in resource use. However, the amount of temporary hired labor, except for period 2 (March and April), and financial resources were freely determined by the model.[5] The results given by the quadratic programming model tend to be reasonably good approximateions of the actual situation. Important observations with respect to land requirements should be noted. Above the Cr$5,594 income level, all classes of

[5]As previously described in Chapter III, the financial resources were divided into two different types: operating and investment capital, which are each subdivided into preferential and normal interest rates. In addition to these differences, there was a constraint on the overall borrowing capacity of the farm.

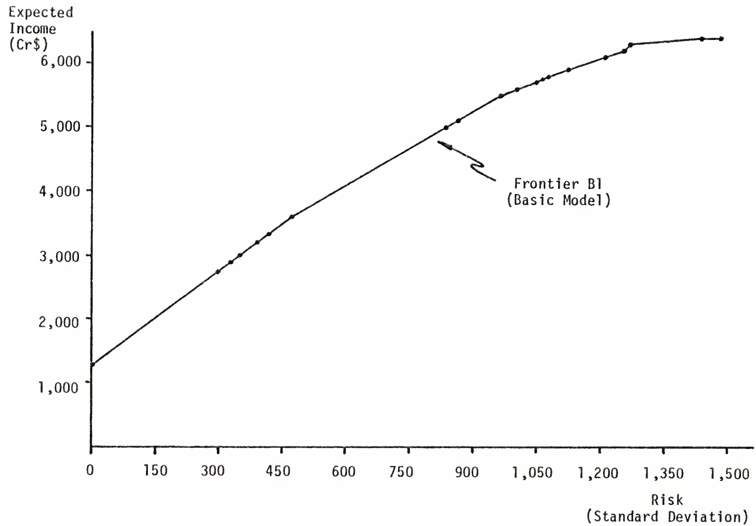

Figure 4. Small farm efficiency frontier for minimum risk farm plans

Table 12. Resource requirements for selected farm plans on basic small farm model efficiency frontier

Item and unit	Selected farm plans					
	1	2	3	4	5	6
Expected income (Cr$)	1,303	2,750	3,324	5,050	5,482	5,594
Land (ha)						
Class "A"	0	0.76	0.86	0.86	0.86	0.86
Class "B"	0	0.12	0.16	0.73	2.62	2.75
Pasture	0	1.77	3.03	7.43	7.43	7.77
Fallow	0	0	0	0	0	0.34
Family labor (m/d)						
1	0.03	33.53	36.17	36.17	36.17	36.17
2	0.03	36.17	36.17	36.17	36.17	36.17
3	0.01	14.00	16.72	23.22	34.73	35.75
4	0.01	12.40	14.35	19.44	23.62	24.16
5	0	1.82	2.75	9.09	23.78	26.55
6	0.01	7.80	9.52	14.36	22.78	23.03
Total	0.09	105.72	116.18	138.45	176.73	186.33
Temporary labor (m/d)						
1	0	0	0	0	2.62	3.02
2	0	0	0	13.07	38.20	40.33
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
Total	0	0	0	13.07	40.32	43.35
Off-farm work (m/d)						
1	36.14	2.64	0	0	0	0
2	36.14	0	0	0	0	0
3	36.16	22.17	19.45	12.95	1.44	0.42
4	36.16	23.77	21.32	16.73	12.55	12.01
5	36.17	34.35	33.42	27.08	12.91	9.62
6	36.16	28.37	26.65	21.81	13.39	8.14
Total	216.93	111.30	100.84	78.57	40.29	30.19
Capital (Cr$)						
Operating	0	289	547	1,373	1,572	1,647
Investment	0	415	712	1,744	1,744	1,824
Credit limit	0	703	1,259	3,117	3,315	3,472

Table 12. Continued

Item and unit	Selected farm plans					Amount available
	7	8	9	10	11	12
Expected income (Cr$)	5,755	5,930	6,129	6,276	6,403	---
Land (ha)						
Class "A"	0.86	0.86	0.86	0.86	0.86	0.86
Class "B"	2.75	2.75	2.75	2.75	2.75	2.75
Pasture	8.43	9.19	10.01	10.65	10.55	7.43
Fallow	1.00	1.76	2.67	3.22	3.22	3.22
Family labor (m/d)						
1	36.17	36.17	36.17	36.17	36.17	36.17
2	36.17	36.17	36.17	36.17	36.17	36.17
3	36.17	36.17	36.17	36.17	36.17	36.17
4	24.65	25.27	26.02	26.91	34.47	36.17
5	31.04	36.17	36.17	36.17	36.17	36.17
6	36.17	36.17	36.17	36.17	36.17	36.17
Total	200.37	206.12	206.37	207.76	215.32	217.02
Temporary labor (m/d)						
1	3.40	3.91	4.49	5.49	12.73	unlimited
2	41.08	42.13	43.42	45.30	72.36	85.00
3	0	0	0	0	0.68	unlimited
4	0	0	0	0	0	unlimited
5	0	0	0	3.66	2.78	unlimited
5	0	4.79	17.27	24.68	25.24	unlimited
Total	44.48	50.83	65.18	79.13	113.79	unlimited
Off-farm work (m/d)						
1	0	0	0	0	0	36.17
2	0	0	0	0	0	36.17
3	0	0	0	0	0	36.17
4	11.52	10.90	10.15	9.25	1.70	36.17
5	5.13	0	0	0	0	36.17
6	0	0	0	0	0	36.17
Total	16.65	10.90	10.15	9.26	1.70	217.00
Capital (Cr$)						
Operating	1,771	1,978	2,274	2,466	2,740	15,600
Investment	1,972	2,156	2,371	2,499	2,499	15,600
Credit limit	3,710	4,133	4,645	4,965	5,239	17,796

land ("A" and "B", plus pasture land) become fully utilized. In addition, fallow land, through the improved fallow activity, starts to be transformed into pasture land. However, even though part of this natural pasture land can be turned into cropland, none of it is transformed. It appears that, even though the small farms in this region have considerable potential to increase crop production by increasing the amount of land under cultivation, they are constrained in some way. One possible explanation is the lack of labor to meet the necessary requirements. Another point, which is not clear, is the question of whether the quality of this natural pasture land is as good as land currently cropped.

As expected in the low income farm plans, family labor is employed in off-farm work rather than in cultivating its own land. This off-farm labor activity would be less risky than otherwise. However, as the variance (risk) increases, this labor gradually is put to work inside the farm and is supplemented with hired temporary labor. It appears that the relatively high return associated with mixed-cropping cotton enterprises causes a shift to the use of more hired temporary labor.

The only resources which never become restrictive along the frontier are financial resources and family labor in period 4 (July and August). Thus, no temporary labor is hired in period 4. Fertilizer use is virtually nonexistent, and only rarely are insecticides and pesticides applied, and seeds are saved from the previous year's harvest. Labor demand is at peaks preceding and following period 4, i.e., during the planting and harvesting seasons, respectively. Cotton harvesting usually begins in late August.

Considering crop mix and diversification, the pattern of enterprise combinations associated with the Cr$5,482 income level is considerably different from that of the linear programmed plan (see Table 11). The lack of diversification among single cotton, cotton/beans/corn, and cotton/beans in the programmed solution is due to the fact that, at the profit maximizing point, enterprise diversification as a means towards risk minimization plays no role. At this point, the only factor determining the selection of production activities is associated with the gross margins and resource productivities of enterprises. It can, therefore, be concluded, especially by contrasting the quadratic programming with the linear programming solutions, particularly those within the Cr$5,482 to Cr$5,594 range, that small farmers in the region apparently do not choose farm plans solely on the basis of profit maximization.

Medium Farm Efficiency Frontier

The initial medium farm efficiency frontier, also referred to as the medium farm basic model frontier, is assumed to represent the actual situation faced by a typical medium farm of the Seridó Region. The major differences of this model, as compared to the previous small farm basic model, are that it does not allow for the family labor to work outside the farm, it includes cattle production at a higher level of technology (forage supplement), and allows sharecropping. Table 13 shows the variance, standard deviation, coefficients of variation, and farm plans for solution points on the medium farm basic model frontier for the range in expected income. The farm plans in this table have expected income levels that range from Cr$1,774 to Cr$10,769 with coefficients of variations that range from zero to .340. A comparison of

Table 13. Variance, standard deviation, coefficient of variation, and minimum risk farm plans for the medium farm, by expected income level

Item and unit	Quadratic programming solutions									
	1	2	3	4	5	6	7	8	9	10
Expected income (Cr$)	1,774	3,240	3,240	3,254	3,380	3,408	4,566	4,617	4,676	4,833
Variance (Cr$)	0	44,878	44,902	45,850	55,029	57,364	205,516	214,476	225,395	260,058
Standard deviation (Cr$)	0	212	212	214	234	240	453	463	475	510
Coefficient of variance	---	.065	.065	.066	.069	.070	.099	.100	.102	.103
Cropping pattern										
Owner-operated area:										
Cotton (ha)	0	0.24	0.23	0.21	0.23	0.27	0.51	0.43	0.44	0.62
Rice (ha)	0	0.80	0.80	0.80	0.88	0.88	1.66	1.69	1.73	1.73
Cotton/beans/corn (ha)	---	---	---	---	---	---	---	---	---	---
Cotton/beans (ha)	---	---	---	---	---	---	---	---	---	---
Cattle (a-u)	0	0	0	0.06	0.06	0.16	0.30	0.48	0.49	1.02
Forage (ha)	---	---	0	0	0	0.01	0.02	0.03	0.03	0.06
Sharecropped area:										
Cassava (ha)	0.34	0.33	0.33	0.33	0.33	0.33	0.32	0.32	0.32	0.31
Cotton/beans/corn (ha)	22.86	22.37	22.37	22.47	22.37	22.27	21.68	21.88	21.78	21.29
No. of sharecroppers	2.32	2.27	2.27	2.28	2.27	2.26	2.20	2.22	2.21	2.16

Table 13. Continued

Item and unit	Quadratic programming solutions								
	11	12	13	14	15	16	17	18	19
Expected income (Cr$)	4,936	5,114	5,152	5,357	5,496	5,936	6,041	5,294	6,320
Variance (Cr$)	287,455	342,992	356,215	437,161	502,144	757,795	829,756	1,025,099	1,046,303
Standard deviation (Cr$)	536	586	597	661	709	870	911	1,012	1,023
Coefficient of variance	.108	.114	.116	.123	.129	.146	.151	.161	.162
Cropping pattern									
Owner-operated area:									
Cotton (ha)	0.71	0.85	0.82	0.98	0.87	1.17	1.10	1.01	0.99
Rice (ha)	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Cotton/beans/corn (ha)	0.05	0.12	0.13	0.20	0.25	0.43	0.47	0.54	0.55
Cotton/beans (ha)	---	0.06	0.05	0.12	0.07	0.20	0.21	0.14	0.14
Cattle (a-u)	1.30	1.76	1.96	2.54	3.23	4.61	5.08	6.26	6.37
Forage (ha)	0.08	0.11	0.12	0.15	0.19	0.28	0.30	0.38	0.38
Sharecropped area:									
Cassava (ha)	0.31	0.30	0.30	0.29	0.29	0.26	0.26	0.26	0.26
Cotton/beans/corn (ha)	20.89	20.20	20.30	19.41	19.61	17.94	17.94	17.94	17.94
No. of sharecroppers	2.12	2.05	2 06	1.97	1.99	1.82	1.82	1.82	1.82

Table 13. Continued

Item and unit	Quadratic programming solutions							
	20	21	22	23	24	25	26	27
Expected income (Cr$)	6,661	6,766	8,352	9,063	9,658	9,833	9,956	10,152
Variance (Cr$)	1,357,243	1,464,699	3,667,255	5,027,640	6,353,731	6,775,923	7,083,914	7,599,572
Standard deviation (Cr$)	1,165	1,210	1,915	2,242	2,521	2,603	2,662	2,757
Coefficient of variance	.175	.179	.229	.247	.261	.265	.267	.272
Cropping pattern								
Owner-operated area:								
Cotton (ha)	1.16	1.18	1.97	1.46	1.65	1.50	1.53	2.30
Rice (ha)	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Cotton/beans/corn (ha)	0.68	0.68	1.30	1.54	1.77	1.80	1.84	2.05
Cotton/beans (ha)	0.21	0.12	0.40	0.20	0.27	0.19	0.21	0.32
Cattle (a-u)	7.58	8.13	14.02	17.52	19.91	20.83	21.34	21.55
Forage (ha)	0.46	0.49	0.84	1.05	1.19	1.25	1.28	1.29
Sharecropped area:								
Cassava (ha)	0.25	0.25	0.20	0.20	0.19	0.19	0.19	0.16
Cotton/beans/corn (ha)	17.15	17.15	13.60	13.90	12.81	12.91	12.71	11.04
No. of sharecroppers	1.74	1.74	1.38	1.41	1.30	1.31	1.29	1.12

Table 13. Continued

Item and unit	Quadratic programming solutions							
	28	29	30	31	32	33	34	35
Expected income (Cr$)	10,176	10,270	10,286	10,296	10,300	10,314	10,316	10,325
Variance (Cr$)	7,669,244	7,954,854	8,008,197	8,040,412	8,055,519	8,106,913	8,110,816	8,145,791
Standard deviation (Cr$)	2,769	2,820	2,830	2,836	2,838	2,847	2,848	2,854
Coefficient of variance	.272	.274	.275	.275	.275	.276	.276	.276
Cropping pattern								
Owner-operated area:								
Cotton (ha)	2.55	2.96	2.92	2.95	2.94	3.03	3.03	2.90
Rice (ha)	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Cotton/beans/corn (ha)	2.10	2.21	2.38	2.39	2.43	2.46	2.47	2.60
Cotton/beans (ha)	0.12	0.17	0.04	0.05	0.01	0.01	---	---
Cattle (a-u)	21.57	21.68	21.68	21.71	21.71	21.71	21.71	21.71
Forage (ha)	1.29	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Sharecropped area:								
Cassava (ha)	0.16	0.15	0.15	0.15	0.14	0.14	0.14	0.14
Cotton/beans/corn (ha)	10.84	9.95	9.95	9.95	9.76	9.66	9.66	9.66
No. of sharecroppers	1.10	1.01	1.01	1.10	0.99	0.98	0.98	0.98

Table 13. Continued

Item and unit	Quadratic programming solutions					LP solution	Actual plan
	36	37	38	39	40	41	42
Expected income (Cr$)	10,450	10,452	10,641	10,666	10,720	10,769	10,182
Variance (Cr$)	8,672,083	8,678,964	9,643,405	9,831,290	10,949,734	13,412,900	---
Standard deviation (Cr$)	2,945	2,946	3,105	3,135	3,309	3,662	---
Coefficient of variance	.282	.282	.292	.294	.309	.340	---
Cropping pattern							
Owner-operated area:							
Cotton (ha)	3.74	3.67	5.03	6.18	9.60	13.71	2.28
Rice (ha)	1.73	1.73	1.73	1.73	1.73	1.73	1.71
Cotton/beans/corn (ha)	2.88	2.92	3.33	2.94	1.60	---	1.81
Cotton/beans (ha)	---	---	---	---	---	---	0.16
Cattle (a-u)	21.71	21.71	21.71	21.71	21.71	21.71	21.68
Forage (ha)	1.30	1.30	1.30	1.30	1.30	1.30	1.68
Sharecropped area:							
Cassava (ha)	0.13	0.13	0.10	0.09	0.06	0.02	0.16
Cotton/beans/corn (ha)	8.57	8.57	6.80	6.11	4.04	1.58	10.54
No. of sharecroppers	0.87	0.87	0.69	0.62	0.41	0.16	1.07

the survey data with the basic model results shows that solutions corresponding to levels of expected income that range from Cr$10,152 to Cr$10,270, with coefficients of variation that range from .272 to .274, appear to be most like the actual plan. The overall allocation of land between landowners and sharecroppers in the Cr$10,176 plan is very close to the actual plan. The cropping pattern of these solutions include cotton, rice, cotton/beans/corn, cotton/beans, and cattle enterprises and are very similar to the actual farm plan.

In the medium basic model frontier, except for isolated beans, corn, cassava, and mixed-cropping beans/corn, which never enter the solution, all activities enter the optimum solution for at least a limited range of expected income. These particular results, and their reasons, are similar to those obtained in the small farm basic model frontier. The reason why isolated corn and mixed-cropping beans/corn do not enter the solution is in part due to the low average labor productivity of these enterprises (see Table 6). In addition to low labor productivity, isolated cassava has a very high coefficient of variation, which implies that its production in relation to other enterprises is more risky. The same condition applies to isolated beans which have a higher coefficient of variation than rice; also, they compete with rice for land class "A".

An important observation regarding the medium basic model frontier is the pattern in which sharecroppers appear in the solutions. The number of sharecroppers starts at 2.32 in the Cr$1,774 income level plan and gradually decreases to .15 in the LP solutions. These results indicate that the sharecropping system is indeed less risky than alternatives. In addition, through the use of sharecropper labor the

landowner can guarantee himself a cheaper source of labor. In general, owner-operated cattle and cotton replace sharecropper cotton/beans/corn as the levels of income and risk increase.

Figure 5 depicts the landowner medium farm frontier. The slope of the efficiency frontier decreases as expected income increases which means that there is an increase in risk per cruzeiro of additional income, i.e., as the expected income of a plan increases so does its riskiness.

The resource requirements for selected farm plans and their availability in the basic medium farm model are given in Table 14. The first plan and the LP solution are given in columns 1 and 12, respectively. The efficient frontier solutions, corresponding to levels of expected incomes ranging from Cr$10,152 to Cr$10,270 are similar to the actual average pattern of resource use. All types of land plus the average amount of family labor are the same in each case.

Sharecropper labor (<u>sujeicão</u>) is practically exhausted after the solution given in column 7, and temporary hired labor only comes into the solutions in critical periods. The amount of permanent labor required by the efficient frontier solutions within this range is similar for periods 1, 2, and 3. The only important discrepencies among resource requirements and their actual average pattern is among the financial resources. As explained previously, this may be due to the technology used in the Seridó Region and the way these resources were specified in the model. However, another possible explanation is the misuse of borrowed money. As several studies indicate, there has been a tendency, in Brazilian agriculture, to transfer profit and self-owned operating capital to activities outside the farm. For financial

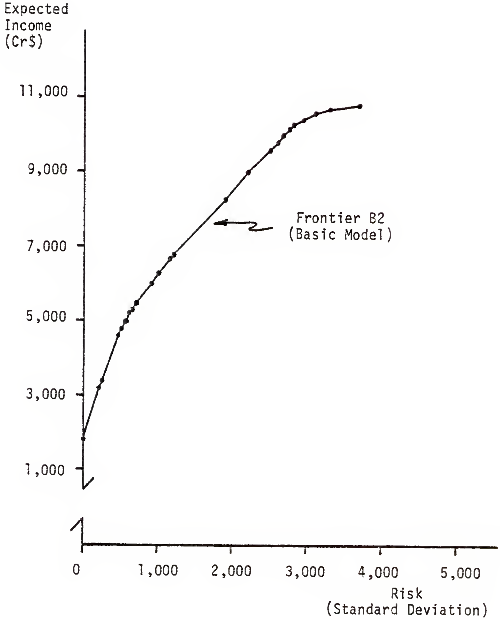

Figure 5. Medium farm efficiency frontier for minimum risk farm plans

Table 14. Resource requirements for selected farm plans on basic medium farm model efficiency frontier

Item and unit	Selected farm plans						
	1	2	3	4	5	6	7
Expected income (Cr$)	1,774	3,380	4,833	5,496	6,766	8,352	9,832
Land (ha)							
Class "A"	0	0.88	1.73	1.73	1.73	1.73	1.73
Class "B"	16.63	16.63	16.63	16.63	16.53	16.63	16.63
Pasture	6.63	6.52	8.84	14.57	28.53	45.34	66.04
Fallow	0	0	0	0	0	0	0
Sharecropping	23.26	22.71	21.63	19.86	17.42	13.85	13.14
Family labor (m/d)							
1	0.06	38.50	38.50	38.50	38.50	38.50	38.50
2	0.06	38.50	38.50	38.50	38.50	38.50	38.50
3	0.02	15.77	32.53	38.50	38.50	38.50	38.50
4	0.02	13.53	27.46	31.40	38.50	38.50	38.50
5	38.50	38.50	38.50	38.50	38.50	38.50	38.50
6	38.50	38.50	38.50	38.50	38.50	38.50	38.50
Total	77.16	183.30	213.99	223.36	231.00	231.00	231.00
Temporary labor (m/d)							
1	0	0	0	0	0	0	0
2	0	0	0	0	7.25	47.45	55.98
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
Total	0	0	0	0	7.25	47.45	55.98
Permanent labor (m/d)							
1	0	0	0	2.89	13.11	28.20	35.30
2	0	0	4.97	20.25	35.30	35.30	35.30
3	0	0	0	0	0	0	6.91
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	1.64	7.21	10.73	5.19	0	0	0
Total	1.64	7.21	10.73	28.34	48.40	63.50	77.51
Sharecropper labor (m/d)							
1	0	0	37.69	37.87	33.21	26.41	25.06
2	0	3.68	41.25	37.87	33.21	25.41	25.06
3	0	0	0	0	9.68	26.41	25.06
4	0	0	0	0	0	10.74	17.73
5	0	0	0	0	1.76	10.23	11.37
6	44.35	43.31	41.25	37.87	33.21	26.41	25.06
Total	44.35	43.31	120.19	113.61	111.07	126.51	129.34
Capital (Cr$)							
Operating	4,464	4,626	5,071	5,496	6,775	8,434	10,661
Investment	0	28	440	1,395	3,510	6,057	9,000
Credit limit	4,464	4,653	5,511	6,891	10,285	14,491	19,661

[a] Limited to 103.23 ha.

[b] Related to the number of sharecroppers in the solution.

Table 14. Continued

Item and unit	Selected farm plans					Amount available
	8	9	10	11	12	13
Expected income (Cr$)	10,152	10,176	10,270	10,450	10,769	---
Land (ha)						
Class "A"	1.73	1.73	1.73	1.73	1.73	1.73
Class "B"	16.63	16.63	16.63	16.63	16.63	16.63
Pasture	67.51	67.51	67.51	67.51	67.51	67.51
Fallow	0	0	0	0	0	19.09
Sharecropping	11.16	10.99	10.09	8.71	1.60	---[a]
Family labor (m/d)						
1	38.50	38.50	38.50	38.50	38.50	38.50
2	38.50	38.50	38.50	38.50	38.50	38.50
3	38.50	38.50	38.50	38.50	38.50	38.50
4	38.50	38.50	38.50	38.50	38.50	38.50
5	38.50	38.50	38.50	38.50	38.50	38.50
6	38.50	38.50	38.50	38.50	38.50	38.50
Total	231.00	231.00	231.00	231.00	231.00	231.00
Temporary labor (m/d)						
1	6.42	6.52	9.25	15.20	19.64	unlimited
2	77.06	76.44	85.84	108.90	137.50	137.50
3	0	0	0	0	40.77	unlimited
4	0	0	0	0	0	unlimited
5	0	0	0	0	45.32	unlimited
6	0	0	0	0	15.09	unlimited
Total	83.48	82.96	95.09	124.10	258.32	unlimited
Oermanent labor (m/d)						
1	35.30	35.30	35.30	35.30	35.30	35.30
2	35.30	35.30	35.30	35.30	35.30	35.30
3	18.72	19.14	24.38	35.30	35.30	35.30
4	0	0	3.11	9.69	17.18	35.30
5	0	0	0	11.46	35.30	35.30
6	0	0	0	7.09	35.30	35.30
Total	89.32	89.74	98.09	134.14	193.68	211.80
Sharecropper labor (m/d)						
1	21.28	20.96	19.24	16.62	3.08	---[b]
2	21.28	20.96	19.24	16.62	3.08	---[b]
3	21.28	20.96	19.24	16.62	3.08	---[b]
4	21.28	20.96	19.24	16.62	3.08	---[b]
5	16.38	16.38	19.24	16.62	3.08	---[b]
6	21.28	20.96	19.24	16.62	3.08	---[b]
Total	122.78	121.73	115.44	99.72	18.48	---[b]
Capital (Cr$)						
Operating	10,748	10,717	10,688	10,793	10,399	15,600
Investment	9,309	9,317	9,164	9,378	9,378	15,600
Credit limit	20,057	20,034	20,052	20.171	19,777	52,018

requirements, farmers tend to rely heavily on institutional credit rather than to use their own capital [Soares, 1976]. Therefore, this practice could be an indication that present credit policies are not so effective as desired.

As expected, all farm plans prefer family and sharecropper labor to other types. Only after these types are exhausted do permanent and temporary hired labor come into the farm plans. The total amount of sharecropper labor and the number of sharecroppers decrease along the efficient frontier. In conclusion it can be said that, in terms of totals, low income farm plans use mostly family and sharecropper labor (sujeicão).

The only resources that do not become restrictive along the frontier are fallow land and financial resources. It is interesting to note that the use of operating capital increases only 130 percent over the whole range of efficient farm plans, i.e., from the first to the LP solution. None of the operating capital offered at the highest interest rate is used. Once again this is a reflection of the nature and level of technology used in the area.

The use of the investment capital never goes beyond the limit of that available at the special low interest rate. It starts to come into the solutions together with the cattle activity. Even though fallow land could be transformed into pasture, through the improved pasture activity, no fallow land was used. Labor appears to be the most restrictive resource. Table 14 indicates that not only are all types of available labor fully used at high income levels, with the exception of permanent and temporary hired labor in some periods, but there is also considerable use of sharecropper labor on the owner-operated part of the

farm mainly in the high income levels of the frontier plans where this type of labor is completely exhausted. This result suggests that one of the major reasons why sharecropping constitutes an attractive alternative in the Seridó Region may be because of the amount of labor it can provide. Another important point is the seasonal nature of labor demand in the region. Periods 1, 2, and 4 are the most restrictive.

Large Farm Efficiency Frontier

The initial large farm efficiency frontier, also referred to as the basic large farm model frontier, is assumed to represent the actual situation faced by the decision-maker of a typical large farm in the Seridó Region. Table 15 presents the variance, standard deviation, coefficients of variation, and farm plans for the solution points on the basic large model frontier. The farm plans show solutions corresponding to levels of expected income that range from Cr$4,006 to Cr$20,685, with coefficients of variation that range from zero to .445, respectively. As in each of the preceding cases, increases in level of income is associated with increases in the level of risk. The major difference in this model, as compared to the medium farm basic model, is that cattle production enters at a higher level of technology (improved forage supplement).[6]

A comparison of the basic model results with the actual farm plan, in column 52 of Table 15, shows that solutions corresponding to levels of expected income ranging from Cr$20,255 to Cr$20,456, with coefficients of variation ranging from .423 to .426, respectively, appear to

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[6]See budgets in Appendix B for comparison.

Table 15. Variance, standard deviation, coefficient of variation, and minimum risk farm plans for the large farm, by expected income level

Item and unit	Quadratic programming solutions									
	1	2	3	4	5	6	7	8	9	10
Expected income (Cr$)	4,006	5,269	5,270	5,271	5,372	5,375	5,376	5,387	5,846	5,916
Variance (Cr$)	0	32,874	32,928	32,947	39,201	39,343	39,452	40,191	81,082	89,404
Standard deviation (Cr$)	0	181	182	182	198	198	199	200	285	299
Coefficient variation	---	.034	.034	.037	.037	.037	.037	.037	.049	.050
Cropping pattern										
Owner-operated area:										
Cotton (ha)	0	0.18	0.17	0.16	0.18	0.19	0.20	0.22	0.31	0.42
Rice (ha)	0	0.69	0.69	0.69	0.75	0.75	0.75	0.75	1.07	1.07
Cotton/beans/corn (ha)	---	---	---	---	---	---	---	---	---	---
Cotton/beans (ha)	---	---	---	---	---	---	---	---	---	---
Cattle (a-u)	0	0	0	0	0	0	0	0.03	0.05	0.24
Forage (ha)	---	---	---	---	---	---	0	0	0	0.02
Sharecropped area:										
Cassava (ha)	0.78	0.77	0.77	0.77	0.77	0.77	0.77	0.77	0.76	0.76
Cotton/beans/corn (ha)	52.92	52.13	52.13	52.23	52.13	52.13	52.03	52.03	51.64	51.44
No. of sharecroppers	5.37	5.29	5.29	5.30	5.29	5.29	5.28	5.28	5.24	5.22

Table 15. Continued

Item and unit	Quadratic programming solutions							
	11	12	13	14	15	16	17	18
Expected income (Cr$)	5,918	6,769	6,842	7,933	7,975	8,079	8,486	9,321
Variance (Cr$)	89,747	318,481	349,890	1,057,915	1,094,576	1,189,452	1,621,411	2,775,217
Standard deviation (Cr$)	300	564	592	1,028	1,046	1,091	1,273	1,666
Coefficient variation	.051	.083	.086	.130	.131	.135	.150	.179
Cropping pattern								
Owner-operated area:								
Cotton (ha)	0.42	1.30	1.22	2.30	2.38	2.49	2.34	3.17
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Cotton/beans/corn (ha)	0	0.36	0.40	0.89	0.88	0.93	1.07	1.46
Cotton/beans (ha)	---	0.39	0.36	0.84	0.78	0.82	0.65	0.92
Cattle (a-u)	0.25	1.94	2.32	4.82	5.02	5.27	7.21	9.70
Forage (ha)	0.02	0.17	0.21	0.43	0.45	0.48	0.65	0.87
Sharecropped area:								
Cassava (ha)	0.76	0.71	0.71	0.66	0.66	0.65	0.65	0.61
Cotton/beans/corn (ha)	51.44	48.49	48.59	44.84	44.74	44.45	44.25	41.49
No. of sharecroppers	5.22	4.92	4.93	4.55	4.54	4.51	4.49	4.21

Table 15. Continued

Item and unit	Quadratic programming solutions						
	19	20	21	22	23	24	25
Expected income (Cr$)	9,720	11,530	11,726	11,729	11,842	11,883	11,918
Variance (Cr$)	3,454,515	7,568,750	8,115,732	8,123,491	8,456,785	8,579,860	8,692,279
Standard deviation (Cr$)	1,859	2,751	2,849	2,850	2,908	2,929	2,948
Coefficient variation	.191	.238	.243	.243	.246	.246	.247
Cropping pattern							
Owner-operated area:							
Cotton (ha)	3.07	4.59	5.13	5.14	5.24	5.44	5.37
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Cotton/beans/corn (ha)	1.59	2.46	2.58	2.61	2.66	2.73	2.75
Cotton/beans (ha)	0.74	1.20	1.29	1.26	1.28	1.28	1.05
Cattle (a-u)	11.60	17.55	17.87	17.87	18.25	18.40	18.66
Forage (ha)	1.04	1.58	1.61	1.61	1.64	1.66	1.68
Sharecropped area:							
Cassava (ha)	0.61	0.52	0.51	0.51	0.50	0.49	0.49
Cotton/beans/corn (ha)	41.29	35.68	34.49	34.49	33.70	33.51	33.21
No. of sharecroppers	4.19	3.62	3.50	3.50	3.42	3.40	3.37

Table 15. Continued

Item and unit	Quadratic programming solutions						
	26	27	28	29	30	31	32
Expected income (Cr$)	12,156	12,178	12,241	13,263	13,446	13,715	14,702
Variance (Cr$)	9,473,117	9,546,341	9,762,495	13,674,090	14,463,757	15,676,401	20,609,003
Standard deviation (Cr$)	3,078	3,090	3,124	3,698	3,803	3,959	4,540
Coefficient variation	.253	.254	.255	.279	.283	.289	.309
Cropping pattern							
Owner-operated area:							
Cotton (ha)	5.61	5.72	5.79	4.79	4.93	4.69	5.38
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Cotton/beans/corn (ha)	2.88	2.90	2.94	3.51	3.61	3.64	4.20
Cotton/beans (ha)	1.03	1.03	1.04	0.78	0.81	0.56	0.67
Cattle (a-u)	19.51	19.51	19.74	25.26	26.00	27.68	31.84
Forage (ha)	1.76	1.76	1.78	2.27	2.34	2.49	2.87
Sharecropped area:							
Cassava (ha)	0.46	0.46	0.46	0.46	0.46	0.46	0.44
Cotton/beans/corn (ha)	31.34	31.24	31.14	31.34	30.94	31.24	29.56
No. of sharecroppers	3.18	3.17	3.16	3.18	3.14	3.14	3.17

Table 15. Continued

Item and unit	Quadratic programming solutions					
	33	34	35	36	37	38
Expected income (Cr$)	14,866	14,889	14,903	14,932	14,963	15,261
Variance (Cr$)	21,498,780	21,630,193	21,710,666	21,890,293	22,088,996	24,061,850
Standard deviation	4,637	4,651	4,659	4,679	4,700	4,905
Cropping pattern	.312	.312	.313	.313	.314	.321
Owner-operated area:						
Cotton (ha)	5.24	5.38	5.46	5.48	5.43	4.89
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07
Cotton/beans/corn (ha)	4.29	4.46	4.48	4.77	4.79	4.93
Cotton/beans (ha)	0.58	0.32	0.32	0.02	---	---
Cattle (a-u)	32.77	32.77	32.77	32.77	32.98	35.01
Forage (ha)	2.95	2.95	2.95	2.95	2.97	3.15
Sharecropped area:						
Cassava (ha)	0.44	0.44	0.43	0.43	0.43	0.44
Cotton/beans/corn (ha)	29.66	29.56	29.47	29.47	29.47	29.76
No. of sharecroppers	3.01	3.00	2.99	2.99	2.99	3.02

Table 15. Continued

Item and unit	Quadratic programming solutions						
	39	40	41	42	43	44	45
Expected income (Cr$)	15,298	15,682	15,683	15,836	15,983	18,193	18,198
Variance (Cr$)	24,309,452	27,023,576	27,030,466	28,176,552	29,299,656	49,353,992	49,408,753
Standard deviation (Cr$)	4,930	5,198	5,199	5,308	5,413	7,025	7,029
Coefficient variation	.322	.331	.332	.335	.339	.386	.386
Cropping pattern							
Owner-operated area:							
Cotton (ha)	4.92	4.58	4.61	4.29	4.37	2.44	2.51
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Cotton/beans/corn (ha)	4.96	5.01	5.00	4.93	5.03	5.36	5.33
Cotton/beans (ha)	---	---	---	---	---	---	---
Cattle (a-u)	35.20	37.74	37.74	38.96	39.74	54.58	54.60
Forage (ha)	3.17	3.40	3.40	3.51	3.58	4.91	4.91
Sharecropped area:							
Cassava (ha)	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Cotton/beans/corn (ha)	29.66	29.66	29.66	29.96	29.66	29.96	29.96
No. of sharecroppers	3.01	3.01	3.01	3.04	3.04	3.04	3.04

Table 15. Continued

Item and unit	Quadratic programming solutions					LP solution	Actual plan
	46	47	48	49	50	51	52
Expected income (Cr$)	20,255	20,257	20,456	20.474	20,514	20,685	20,392
Variance (Cr$)	73,491,357	73,510,534	76,131,142	76,393,011	77,395,164	88,593,280	---
Standard deviation (Cr$)	8,573	8,574	8,725	8,740	8,797	9,412	---
Coefficient variation	.423	.423	.426	.427	.429	.445	---
Cropping pattern							
Owner-operated area:							
Cotton (ha)	0.72	0.76	0.59	1.30	3.42	15.02	0.34
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07	1.04
Cotton/beans/corn (ha)	5.62	5.60	5.63	5.36	4.52	---	5.12
Cotton/beans (ha)	---	---	---	---	---	---	---
Cattle (a-u)	68.49	68.49	69.85	69.85	69.85	69.85	70.00
Forage (ha)	6.16	6.16	6.29	6.29	6.29	6.29	5.46
Sharecropped area:							
Cassava (ha)	0.44	0.44	0.44	0.44	0.42	0.32	0.47
Cotton/beans/corn (ha)	30.16	30.16	30.16	29.76	28.48	21.48	31.93
No. of sharecroppers	3.06	3.06	3.06	3.02	2.89	2.18	3.24

be similar to the large farmers' actual choice. The cropping pattern of these three solutions, including cotton, rice, cotton/beans/corn, cotton/beans, and cattle enterprises, also corresponds closely to the actual farm plan. Except for isolated cotton, which enters the solutions at approximately twice as much as the actual plan, all other enterprise combinations are reasonably well represented in the frontier solutions between Cr$20,255 and Cr$20,456. Aside from possible inaccuracies in the data used, this difference could be explained by the fact that the quadratic programming model used in this study accounts for only the first two moments of the enterprise gross return distributions (excepted value and variance). The third moment, which measures the skewness in the distribution of gross returns, is excluded.

Except for isolated beans, corn and cassava,[7] and mixed-cropping beans/corn, which never enter the frontier plans, all other activities enter the optimum solutions for at least a limited range of expected income. As explained previously, this may be due to their higher coefficients of variation when compared to those activities that entered the solutions (see Table 6). Another reason for this outcome is the low average labor productivity associated with these enterprises when compared to the average labor productivity associated with those activities in the solutions. In general, owner-operated cattle and cotton replace sharecropper cotton/beans/corn as the levels of income and risk increase.

The pattern in which sharecropper activity appears in the solution of the large farm basic model frontier is fairly consistent with that of

[7]Even though cassava does not enter the solutions on the owner-operated part of the farm, it does appear on the sharecropper part because of the sharecropper and his family's consumption requirements.

the medium farm basic model frontier. The number of sharecroppers starts at 5.37 in the Cr$4,006 income plan of column 1 and gradually decreases to 2.18 in the LP solution of column 52. These results are consistent with those of the medium farm basic model frontier and indicate that sharecropping is less risky than alternative activities.

Figure 6 depicts the landowner large farm frontier. Each point on the curve denotes a minimum risk farm plan for the corresponding level of expected income. The slope of the landowner large farm efficiency frontier decreases as expected income increases which suggests an increase in risk per cruzeiro of additional income.

Table 16 presents the resource requirements for selected farm plans and their availability in the basic large farm model. Column 1 gives the first solution, while the LP solution is presented in column 12. The efficient frontier solution at the level of expected income of Cr$20,456 (column 11) is similar to the actual average pattern of resource use on large sharecropper farms. All classes of land and labor considered in the model, except for temporary hired labor, are almost the same in the two solutions. Cropland "A" is completely exhausted after the expected income level of Cr$6,842 (column 3), while cropland "B" is completely exhausted starting from the very first solution (column 1). Pasture land gradually increases in the solutions in proportion to increases in cattle enterprises, while fallow land is untouched throughout the efficiency frontier. Up to the expected income level of Cr$11,883 part of pasture land is transformed into cropland "B" and used in sharecropping. As expected, sharecropping land decreases as the numbers of sharecroppers diminish.

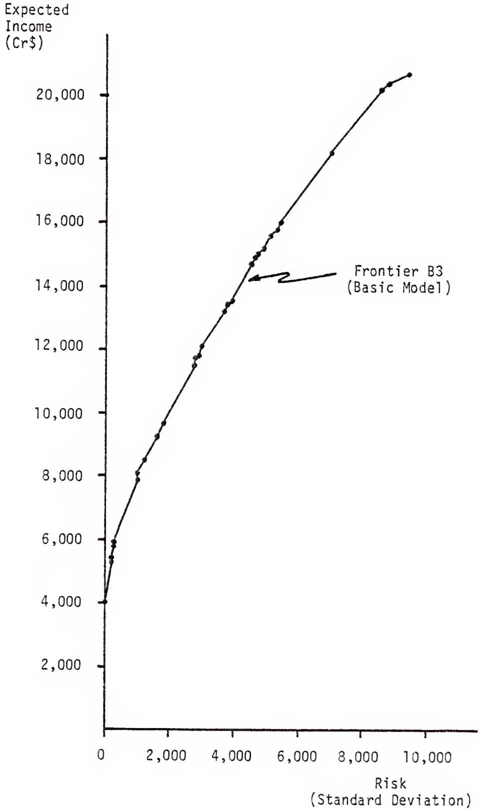

Figure 6. Large farm efficiency frontier for minimum risk farm plans

Table 16. Resource requirements for selected farm plans on basic large farm model efficiency frontier

Item and unit	Selected farm plans						
	1	2	3	4	5	6	7
Expected income (Cr$)	4,006	5,372	6,342	8,079	9,720	11,683	13,253
Land (ha)							
Class "A"	0	0.75	1.07	1.07	1.07	1.07	1.07
Class "B"	43.13	43.13	43.13	43.13	43.13	43.13	43.13
Pasture	10.62	9.93	16.53	25.30	46.21	56.70	83.16
Fallow	0	0	0	0	0	0	0
Sharecropping	53.75	52.38	49.30	45.03	41.94	33.39	31.78
Family labor (m/d)							
1	0.06	32.90	32.90	32.90	32.90	32.90	32.90
2	0.06	32.90	32.90	32.90	32.90	32.90	32.90
3	0.02	13.35	32.90	32.90	32.90	32.90	32.90
4	0.02	11.51	23.87	32.90	32.90	32.90	32.90
5	32.90	32.90	32.90	32.90	32.90	32.90	32.90
6	32.90	32.90	32.90	32.90	32.90	32.90	32.90
Total	114.46	136.46	188.37	197.40	197.40	197.40	197.45
Temporary labor (m/d)							
1	0	0	0	0	0	0	0
2	0	0	0	0	0	78.05	94.93
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
Total	0	0	0	0	0	78.06	94.93
Permanent labor (m/d)							
1	0	0	0	0	0	0	0
2	0	0	0	0	30.93	30.93	30.93
3	0	0	0	0	0	0	12.46
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
Total	0	0	0	0	30.93	30.93	43.39
Sharecropper labor (m/d)							
1	0	0	19.56	27.18	35.02	50.05	58.50
2	0	2.99	47.30	35.98	79.37	64.31	50.50
3	0	0	0	18.30	33.02	64.31	50.50
4	0	0	0	0.38	11.71	29.58	33.43
5	28.80	26.14	32.73	42.31	49.38	64.31	60.50
6	102.50	100.85	34.01	85.38	79.37	59.15	43.24
Total	131.30	129.98	133.65	251.23	290.67	333.21	323.37
Capital (Cr$)							
Operating I	10,361	10,590	11,137	11,724	12,325	15,600	15,600
Operating II	0	0	0	0	0	0	2,333
Investment I	0	0	1,103	2,511	5,521	6,760	12,022
Investment II	0	0	0	0	0	0	0
Credit limit	10,361	10,590	12,240	14,225	19,346	24,360	29,355

aLimited to 231.70 ha.

bRelated to the number of sharecroppers in the solution.

Table 16. Continued

Item and unit	Selected farm plans					Amount available
	8	9	10	11	12	13
Expected income (Cr$)	15,261	18,198	20,257	20,456	20,585	---
Land (ha)						
Class "A"	1.07	1.07	1.07	1.07	1.07	1.07
Class "B"	43.13	43.13	43.13	43.13	43.13	43.13
Pasture	123.59	192.73	241.78	246.56	246.36	246.56
Fallow	0	0	0	0	0	0
Sharecropping	30.16	30.38	30.60	30.62	21.33	---[a]
Family labor (m/d)						
1	32.90	32.90	32.90	32.90	32.90	32.90
2	32.90	32.90	32.90	32.90	32.90	32.90
3	32.90	32.90	32.90	32.90	32.90	32.90
4	32.90	32.90	32.90	32.90	32.90	32.90
5	32.90	32.90	32.90	32.90	32.90	32.90
6	32.90	32.90	32.90	32.90	32.90	32.90
Total	197.40	197.40	197.40	197.40	197.40	197.40
Temporary labor (m/d)						
1	0	0	11.76	12.31	9.33	unlimited
2	123.32	125.00	125.00	125.00	125.00	125.00
3	0.39	12.19	19.72	20.44	64.03	unlimited
4	0	0	0	1.36	0.75	unlimited
5	0	0	0	0	32.60	unlimited
6	0	0	0	0	42.53	unlimited
Total	124.71	137.19	156.48	159.11	323.84	unlimited
Permanent labor (m/d)						
1	14.08	30.93	30.93	30.93	30.93	30.93
2	30.93	30.93	30.93	30.93	30.93	30.93
3	30.93	30.93	30.93	30.93	30.93	30.93
4	0	16.96	30.93	30.93	30.93	30.93
5	18.55	23.50	25.40	25.56	30.93	30.93
6	0	11.30	19.77	20.54	30.93	30.93
Total	94.49	145.05	169.39	170.32	185.58	185.58
Sharecropper labor (m/d)						
1	57.51	57.93	58.35	58.40	41.63	---[b]
2	57.51	57.93	58.35	58.40	41.63	---[b]
3	57.51	57.93	58.35	58.40	41.63	---[b]
4	54.45	57.93	58.35	58.40	41.63	---[b]
5	57.51	57.93	58.35	58.40	41.63	---[b]
6	57.51	57.93	58.35	58.40	41.63	---[b]
Total	342.00	347.58	350.10	350.40	249.78	---
Capital (Cr$)						
Operating I	15,600	15,600	15,066	15,600	15,600	15,600
Operating II	6,320	14,222	13,840	20,389	19,525	0
Investment I	15,600	15,600	15,600	15,600	15,600	16,600
Investment II	1,066	10,389	17,303	17,547	17,547	0
Credit limit	38,586	55,311	58,043	59,206	58,372	118,209

Family labor is practically exhausted after the expected income level of Cr$5,372 (column 2). Sharecropper labor gradually increases up to the expected income level of Cr$11,883, after which it is practically exhausted and decreases as the number of sharecroppers in the farm plans decrease. Permanent labor begins to be a major source of labor after the expected income level of Cr$15,261 (column 8) and temporary hired labor only comes into the solutions in critical periods.

As expected, family and sharecropper labor enter all farm plans ahead of other types of labor. At high levels of expected income, all types of labor are fully employed. The considerable amount of sharecropper labor used in the owner-operated part of the farm in all farm plans suggests the importance of sharecropping not only as a way of reducing risk but as a major source of labor.

Similar to the small and medium farm models, the only important discrepancy among resource requirements and their actual average pattern is among the financial resources. The explanation of this outcome for the large farm is similar to that given for the medium farm.

An interesting observation regarding the financial resources is that the overall financial requirements given by the last row in Table 16 (credit limit) increase continuously and reach their maximum of Cr$69,236 as the expected income level of Cr$20,456 as shown in column 11. In the next column, which represents the LP solution, the total financial requirement decreases to Cr$68,372. The reason for this decline in the overall financial requirements of the LP solution is that after the expected income level of Cr$20,456, the level of the cattle enterprise is restricted by the availability of labor. In addition, there is a considerable change in the cropping pattern; cotton/beans/corn

is completely replaced by isolated cotton for which the capital requirement is considerably less (see Table 15). Low income farm plans use both operating and investment capital at preferential interest rates (less than Cr$15,600 for each). As the farm-decision maker moves toward higher income farm plans, more operating and investment capital are used. Therefore, operating and investment capital at preferential interest rates become restrictive, so that additional operating and investment capital at normal interest rates are used. This change is a result of the gradual increase in cattle enterprise along the farm efficiency frontier. Cattle enterprises on the large farms require considerably more operating and investment capital than do alternative activities.

Summary

The pattern of enterprise combinations generated by the quadratic programming solutions for each farm size, considered in this study, reflects a considerable improvement over the risk-neutral conventional linear programming approach, since the former accounts for variance in returns as well as the level of returns. This additional information is used to explain the similarities between certain risk-reducing frontier plans and the actual plans. Even though other types and sources of risk, such as the impact of technology, have not been considered in the analysis, by contrasting the quadratic with the linear programming solutions for each farm size, it can be concluded that farmers in the study area apparently do not choose farm plans solely on the basis of level of profit. A related conclusion is reached when the different farm sizes are contrasted. Actual farm plans appear to reflect resource employment in such a way that desired levels of income

are reached at minimum risk. Although the expected income is lower, considerably less income variability occurs over the years. The smaller the amount of resources available to the farmer, the more he prefers farm plans with less income variability rather than higher expected income levels.

In the study area, the level of risk aversion decreases as size of farm increases. In other words, as farm size increases, riskier farm plans are chosen by farmers. The level of risk, on each farm size, increased at an increasing rate as the level of income increased.

On the resource side, it was found that land is a restrictive factor only for the sharecroppers and small farmers. Labor is the most limiting factor for the medium and large farmers. For the small farmers, labor appears to be a restrictive factor only in critical months. Given the forms of technology used in the study area, the amount of credit is not a limiting factor for the majority of the farmers. With the exception of sharecroppers, the results indicate a surplus of financial resources vis-a-vis their actual requirements. This surplus decreases as farm size increases. Since most of the sharecroppers' operating capital comes from the landowner, the relaxing of the compensation costs on sharecropping activities would probably increase the number of sharecroppers. In addition, any improvement in technology, regardless of the size of the farm, will require higher amounts of operating and investment capital.

On the small farm, the major changes in activities associated with increases in levels of income and risk were increases in cattle and cotton/beans/corn and a decrease in off-farm work. On medium and large farms, owner-operated cattle and cotton tended to replace sharecropper

cotton/corn/beans as the levels of income and risk increased. Thus, it appears that the sharecropping system is a means of lowering risks faced by landowners.

CHAPTER V
EFFECTS OF SELECTED POTENTIAL CHANGES

This chapter deals with an evaluation and comparison of the effects of potential agricultural policies on different farm sizes in the Seridó region of Northeastern Brazil. The results reported in this chapter represent an attempt to fulfill objective four as stated in the first chapter. Four types of alternatives are evaluated for their possible impact on different farm sizes with respect to income, cropping pattern, and resource use. First, the effects of replacing sharecroppers by other forms of labor available to the landowner are presented. Second, a hypothetical situation where cotton activities are removed from the farm plans is evaluated. Third, the effects of a change in the price of cotton are analyzed. Fourth, effects of a reduction in credit availability are investigated. In addition, the reasons for considering each type of alternative analyzed are discussed. Finally, the effects of the selected potential changes on income are evaluated if risk preference is assumed to be unchanged.

Effects of Replacing Sharecroppers by Other Forms of Labor

The objective of this analysis is to compare the relative risk of using sharecroppers against other forms of labor available to the landowner in different farm sizes. Only two farm sizes are considered, medium and large, since sharecroppers are seldom employed on small farms. Removing sharecroppers as an alternative source of labor would require

farmers in the Seridó region to rely on family, permanent, and/or temporary hired labor. To accomplish this purpose, two efficiency frontiers were derived, one for each farm size.

Medium Farm

The standard deviation, coefficient of variation, and minimum risk farm plans for frontier A2 (no sharecroppers in the medium farm) by expected income level are given in Table 17. The coefficient of variation for each farm plan shown in Table 17 is higher than the coefficient of variation of the comparable farm plan (in terms of income level) of the basic model as presented in Table 13.

Figure 7 shows the basic model frontier B2 and frontier A2. The result of eliminating sharecroppers from the medium farm model is to shift the efficiency frontier down and to the right, which implies less income for a given level of risk for each farm plan. The standard deviation at each income level tends to be about Cr$500 greater for frontier A2.

The crop-mix, as shown in Table 17, changes considerably as more risky activities come into the solutions in larger amounts. The resource requirements for selected farm plans of the efficienct frontier A2 are presented in Table 18. As expected, each of these farm plans uses more temporary hired and/or permanent labor than the comparable farm plan in the basic model (see Table 14). There would also be much more surplus land, especially in the lower income solutions. Fallow land is never used and financial resources are not restrictive. At the maximum feasible income level of Cr$10,655, farmers would only need 40 percent of the available operating and investment capital.

Table 17. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier A2 (no sharecroppers on the medium farm), by expected income level

Item and unit	Quadratic programming solutions									LP solution
	1	2	3	4	5	6	7	8	9	10
Expected income (Cr$)	1,500	1,800	2,700	3,500	5,000	5,700	6,700	8,700	9,700	10,655
Standard deviation (Cr$)	210	262	431	594	1,047	1,320	1,718	2,567	3,052	3,817
Coefficient of variation	.140	.145	.160	.170	.209	.233	.256	.295	.315	.358
Cropping pattern										
Owner-operated areas:										
Cotton (ha)	0.39	0.62	1.02	1.49	3.39	3.11	4.11	5.66	5.94	15.33
Rice (ha)	0.76	0.86	1.40	1.73	1.73	1.73	1.73	1.73	1.73	1.32
Beans (ha)	---	---	---	---	---	---	---	---	---	0.41
Cotton/beans/corn (ha)	---	---	---	0.09	0.51	0.79	1.13	1.86	2.08	---
Beans/corn (ha)	---	0.04	0.10	---	---	---	---	---	---	---
Cotton/beans (ha)	0.03	0.02	0.02	0.10	0.52	0.44	0.68	0.99	0.54	---
Cattle (a-u)	0	0.18	0.38	1.21	4.07	7.48	10.20	16.81	21.71	21.71
Forage (ha)	---	0.01	0.02	0.07	0.24	0.44	0.61	1.01	1.30	1.30

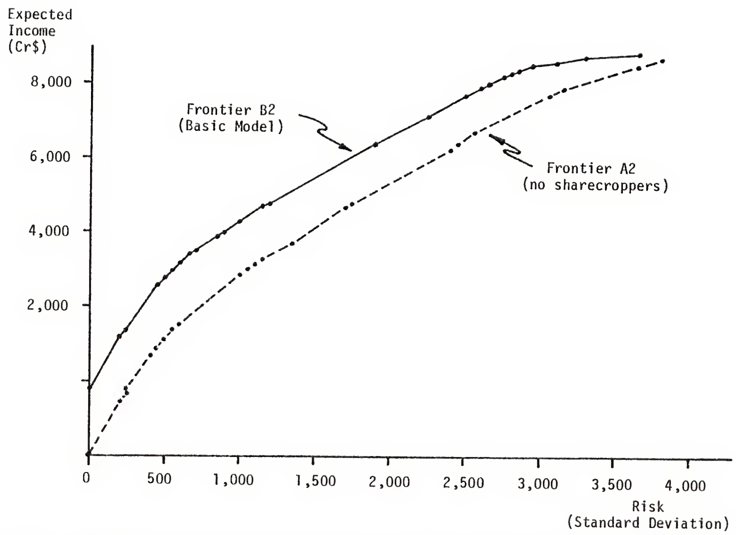

Figure 7. Medium farm efficiency frontiers B2 and A2 (no sharecroppers) for minimum risk farm plans

Table 18. Resource requirements for selected farm plans on efficiency frontier A2 (no sharecroppers for the medium farm), by expected income level

Item and unit	Selected farm plans									LP solution
	1	2	3	4	5	6	7	8	9	10
Expected income (Cr$)	1,500	1,800	2,703	3,500	5,000	5,700	6,700	8,700	9,700	10,655
Land (ha)										
Class "A"	0.76	0.91	1.50	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Class "B"	0.42	0.65	1.06	1.76	4.67	4.78	6.54	9.52	9.86	16.63
Pasture	0	0.56	1.14	3.78	12.65	23.25	31.74	52.28	67.51	67.51
Fallow	0	0	0	0	0	0	0	0	0	0
Family labor (m/d)										
1	33.16	38.50	38.50	38.50	38.50	38.50	38.50	38.50	38.50	38.50
2	38.50	38.50	38.50	38.50	38.50	38.50	38.50	38.50	38.50	38.50
3	14.70	18.04	29.34	38.50	38.50	38.50	38.50	38.50	38.50	38.50
4	11.88	15.55	26.18	29.62	38.50	38.50	38.50	38.50	38.50	38.50
5	3.16	5.40	9.04	13.75	36.52	38.50	38.50	38.50	38.50	38.50
6	8.20	10.52	17.25	23.01	37.57	38.50	38.50	38.50	38.50	38.50
Total	109.60	126.51	158.81	181.88	228.09	231.00	231.00	231.00	231.00	231.00
Temporary labor (m/d)										
1	0	0	0	3.85	10.30	13.38	18.26	28.05	30.82	8.08
2	0	0	0	23.90	63.61	68.04	93.43	137.50	137.50	137.50
3	0	0	0	0	0	0	0	22.40	25.87	47.40
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	3.36	7.81	63.31
6	0	0	0	0	0	0	0	0	0	23.56
Total	0	0	0	27.75	73.91	81.42	111.69	191.31	202.00	279.85
Permanent labor (m/d)										
1	0	0	24.06	35.30	35.30	35.30	35.30	35.30	35.30	35.30
2	0	7.21	35.30	35.30	35.30	35.30	35.30	35.30	35.30	35.30
3	0	0	0	0.44	19.83	22.80	35.30	35.30	35.30	35.30
4	0	0	0	0	0	3.72	10.25	23.15	26.60	27.99
5	0	0	0	0	0	0	14.06	35.30	35.30	35.30
6	0	0	0	0	0	1.54	10.93	28.00	32.11	35.30
Total	0	7.21	59.36	71.04	90.43	98.66	141.14	192.35	199.91	204.49
Capital (Cr$)										
Operating	2	104	479	1,019	2,386	3,594	4,947	7.956	9,662	10,239
Investment	0	78	159	525	1,757	3,230	4,409	7,262	9,378	9,378
Credit limit	2	182	638	1,544	4,143	6,824	9,356	15,218	19,040	19,617

Within the plans of frontier A2, additional land and labor are used to increase the cattle and cotton activities as the levels of income and risk increase.

Large Farm

Figure 8 presents the basic model frontier B3 and frontier A3 in which sharecroppers are excluded. The numerical data for frontier A3 are given in Tables 19 and 20. Elimination of sharecroppers shifts the efficiency frontier down and to the right, implying less income for a given level of risk. Generally, the expected income is about Cr$4,000 less for each level of risk and the standard deviation is Cr$2,000 to Cr$3,000 greater for each income level. Also, the maximun income as determined by LP is Cr$3,000 lower in frontier A3 compared to frontier B3. The risk experienced by large farmers is considerably greater than the one experienced by medium farmers. Therefore, it is unlikely that farm plans of frontier A3 would be considered desirable by most large farmers when frontier B3 provides an alternative. The crop-mix pattern changes to more risky crops, especially in the high expected income solutions. Within frontier A3, mixed-cropping activities are reduced as farm plans move to higher expected income levels, up to a point where no mixed-crops appear in the solutions (Table 19). Higher income levels are achieved by using additional land and labor to increase cotton and cattle production.

As expected, family labor is exhausted at much lower expected income levels than in the basic model frontier B3. The sharecropper labor used in the basic model is replaced by temporary hired labor and by permanent hired labor. At the maximum feasible income level of

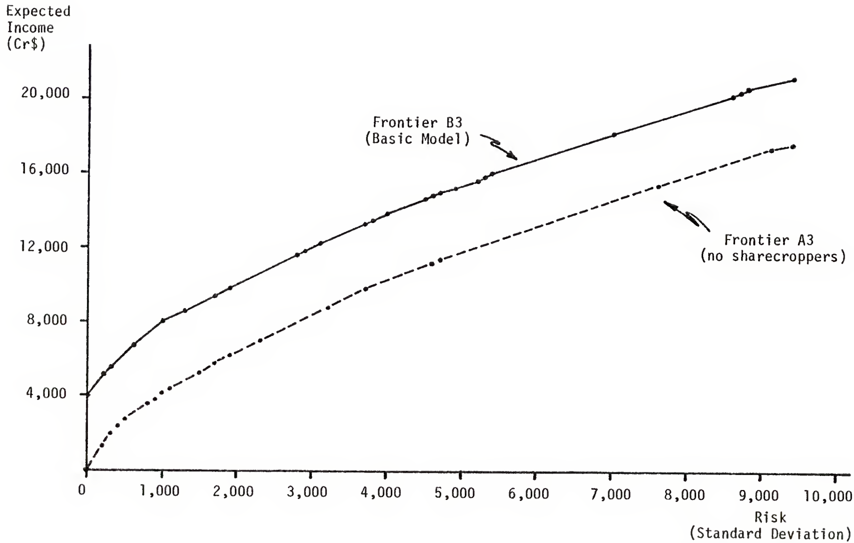

Figure 8. Large farm efficiency frontiers B3 and A3 (no sharecroppers) for minimum risk farm plans

Table 19. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier A3 (no sharecroppers on the large farm), by expected income level

Item and unit	Quadratic programming solutions											LP solution
	1	2	3	4	5	6	7	8	9	10	11	12
Expected income (Cr$)	1,500	2,000	2,800	3,700	4,500	6,000	7,000	8,900	9,700	11,500	15,500	17,685
Standard deviation (Cr$)	211	303	515	808	1,133	1,803	2,268	3,250	3,705	4,712	7,640	9,414
Coefficient of variation	.141	.152	.184	.218	.252	.300	.324	.365	.382	.410	.493	.532
Cropping pattern												
Owner-operated area:												
Cotton (ha)	0.46	0.75	1.79	2.92	3.26	4.92	6.22	7.02	7.06	9.50	11.34	15.52
Rice (ha)	0.75	1.02	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	---
Beans (ha)	---	---	---	---	---	---	---	---	---	---	---	1.07
Cotton/beans/corn (ha)	---	---	0.23	0.52	0.84	1.45	1.88	2.39	2.27	1.24	---	---
Beans/corn (ha)	0.01	0.05	---	---	---	---	---	---	---	---	---	---
Cotton/beans (ha)	---	0.02	0.34	0.59	0.54	0.83	1.10	---	---	---	---	---
Cattle (a-u)	0	0.06	1.05	2.57	5.43	9.67	12.37	21.13	25.30	32.93	57.10	69.85
Forage (ha)	---	0	0.09	0.23	0.49	0.87	1.01	1.90	2.28	2.96	5.14	6.29

Table 20. Resource requirements for selected farm plans on efficiency frontier A3 (no sharecroppers on the large farm), by expected income level

Item and unit	Selected farm plans											LP solution
	1	2	3	4	5	6	7	8	9	10	11	12
Expected income (Cr$)	1,500	2,000	2,000	3,700	4,500	6,000	7,000	8,900	9,700	11,500	15,500	17,685
Land (ha)												
Class "A"	0.76	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Class "B"	0.46	0.78	2.24	4.27	5.14	8.07	10.31	11.31	11.61	13.71	16.49	21.81
Pasture	0	0.21	3.70	9.09	19.17	34.13	43.65	74.60	89.31	116.26	201.57	246.56
Fallow	0	0	0	0	0	0	0	0	0	0	0	0
Family labor (m/d)												
1	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
2	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
3	14.78	21.20	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
4	12.24	18.19	22.07	27.87	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
5	3.61	6.39	18.79	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
6	8.39	12.34	20.61	39.73	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
Total	104.82	123.92	160.17	189.20	197.40	197.40	197.40	197.40	197.40	197.40	197.40	197.40
Temporary labor (m/d)												
1	0	0	0	0	0	4.00	10.26	17.01	19.95	22.49	37.63	10.31
2	0	0	15.80	40.09	53.06	93.70	125.00	125.00	125.00	125.00	125.00	125.00
3	0	0	0	0	0	9.12	24.72	33.08	36.69	48.60	73.11	95.63
4	0	0	0	0	0	0	0	0	0	4.65	24.91	58.43
5	0	0	0	0	0	0	17.71	20.77	32.67	52.01	82.83	134.84
6	0	0	0	0	0	0	0	9.23	13.26	27.05	54.76	82.09
Total	0	0	15.80	40.09	53.06	106.90	177.69	213.09	227.57	279.86	398.24	506.30
Permanent labor (m/d)												
1	0	12.32	17.88	22.22	26.32	30.93	30.93	30.93	30.93	30.93	30.93	30.93
2	5.29	20.92	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
3	0	0	0	12.19	19.30	30.93	30.93	30.93	30.93	30.93	30.93	30.93
4	0	0	0	0	0	11.24	19.33	27.18	30.93	30.93	30.93	30.93
5	0	0	0	0	7.52	30.93	30.93	30.93	30.93	30.93	30.93	30.93
6	0	0	0	0	2.59	18.48	30.29	30.93	30.93	30.93	30.93	30.93
Total	5.29	33.24	48.81	65.34	86.66	153.44	173.34	181.83	185.58	185.58	185.58	185.58
Capital (Cr$)												
Operating	34	225	807	1,663	2,963	5,355	6,998	10,628	12,334	15,600	15,600	15,600
Invesmtent	0	28	499	1,225	2,585	4,602	5,086	10,060	12,042	15,600	15,600	15,600
Credit limit	34	253	1,306	2,888	5,548	9,957	12,884	20,688	24,376	31,277	52,794	64,485

Cr$17,685 in frontier A3, 56 percent more temporary hired labor is used than is used in the maximum feasible income level of Cr$20,685 in the basic model frontier B3.

For frontier A3, all land and financial resource requirements would be considerably reduced. Even at the LP solution given in column 12 of Table 20, more than 50 percent of cropland "B" and more than 50 percent of total financial resources would be unused. The simulation in which sharecroppers were excluded, as well as all other simulations had a restriction imposed on temporary hired labor in period 2. If medium and large landowners were faced with no sharecroppers but an unlimited supply of temporary hired labor, it would be expected that the amount of land utilized would still be much less than that used under the basic model situations B2 and B3 because of financial resource restraints.[1] Temporary hired labor requires much more operating capital than do sharecroppers.

It can be concluded that, given the traditional technology used in the study area, it would be very difficult for farmers to achieve more intensive levels of land use without employing sharecroppers. In addition, the elimination of sharecroppers would affect large farmers more than it would affect medium farmers. In other words, the larger the farm is, the more difficult it would be for farmers to achieve more intensive use of land without employing sharecroppers.

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[1]Empirical evidence of this is presented by the study conducted by Soares for Quixada, State of Ceara, where the exclusion of sharecroppers, but under the assumption of an unlimited supply of temporary labor for large farms, was simulated in a similar way [Soares, 1977].

Removing Cotton From the Farm Plan

From the results discussed in Chapter IV, labor appears to be a scarce resource to medium and large farmers and even to small farmers in the periods of peak demand. Sharecroppers are a major source of labor for landowners. Given the labor requirements of cotton activities, sharecroppers provide labor for the sharecropped part of the farm. They are required by the sharecropping contract to work a certain number of days per week on the owner-operated part of the farm (sujeicão labor), and eventually they provide the source for part of the temporary hired labor. However, structural changes regarding the socio-economic environment may affect the supply of sharecroppers. In fact, according to several farmers and extension agents interviewed by the author, it is already becoming difficult to find an "adequate" number of sharecroppers. This is so because of new alternatives offered to landless agricultural workers. In addition, the political and socio-economic power of the large landowners is declining. Therefore, assuming no significant change in technology and a decline in the supply of labor, one possible economic alternative for farmers in the area is the conversion of cotton land, especially sharecropped land, into livestock production, for which labor requirements are considerably less than for cotton. To determine the effects of the deletion of cotton as an alternative, cotton activities were removed from the farm plans in the analysis. This exercise was accomplished in two ways. First, one extreme situation in which no cotton was allowed in either the owner-operated or the sharecropped part of the farm was simulated. Second, a less extreme situation in which

cotton was removed only from the owner-operated part of the farm was simulated.

Small Farm

The efficiency frontier C1, in which no cotton was allowed, and the basic model efficiency frontier B1 for the small farm are given in Figure 9. The numerical data are given in Tables 21 and 22. Up to the Cr$4,900 level of expected income, the new frontier coincides with the basic model, while beyond this point it lies below. This means that there is a risk-increasing impact on the farm plans above Cr$4,900. In addition, the new LP solution also generates a level of income 12 percent lower than that of the basic model. A comparison between the farm plans in frontier B1 and C1 indicates less enterprise diversification for the new frontier and, consequently, higher coefficients of variation for comparable income levels. Only rice and cattle enterprises come into the solutions along the entire frontier C1. Compared to the basic model, cropland "B" is totally unused when starting from the income level of Cr$5,300 and fallow land is transformed into pasture land and is completely exhausted in the LP solution. Less family labor is used and, thus, more family labor is available to work outside the farm. Permanent labor is considerably reduced and no significant amount of temporary hired labor is employed. As expected, less financial resources are used in all solutions along the new frontier. At the last feasible solution with an income level of Cr$5,608, more than 15 percent of the financial resources would be unused.

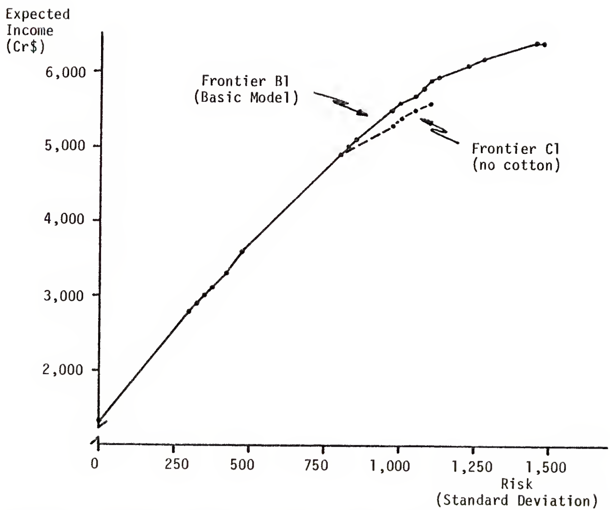

Figure 9. Small farm efficiency frontiers B1 and C1 (no cotton) for minimum risk farm plans

Table 21. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier C1 (no cotton on the small farm), by expected income level

Item and unit	Quadratic programming solutions				LP solution
	1	2	3	4	5
Expected income (Cr$)	4,900	5,300	5,400	5,500	5,608
Standard deviation (Cr$)	798	969	1,012	1,040	1,096
Coefficient of variation	.169	.183	.187	.189	.195
Cropping pattern					
Rice (ha)	0.86	0.86	0.86	0.86	0.86
Cattle (a-u)	9.91	12.38	12.99	13.40	14.20

Table 22. Resource requirements for selected farm plans on efficiency frontier C1 (no cotton on the small farm), by expected income level

Item and unit	Selected farm plans				LP solution
	1	2	3	4	5
Expected income (Cr$)	4,900	5,300	5,400	5,500	5,608
Land (ha)					
Class "A"	0.86	0.86	0.86	0.86	0.86
Class "B"	0	0	0	0	0
Pasture	7.43	9.28	9.74	10.05	10.65
Fallow	0	1.85	2.31	2.62	3.22
Family labor (m/d)					
1	36.17	36.17	36.17	36.17	36.17
2	36.17	36.17	36.17	36.17	36.17
3	17.93	18.87	19.10	19.26	19.56
4	16.66	17.60	17.84	17.99	18.30
5	3.76	16.45	19.60	21.70	25.81
6	11.02	36.17	36.17	36.17	36.17
Total	121.71	161.43	165.05	167.46	172.18
Temporary labor (m/d)					
1	0	0	0	0	0
2	0	0	0	0	0.20
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	4.18	12.35
Total	0	0	0	4.18	12.35
Permanent labor (m/d)					
1	3.69	4.31	4.46	4.56	4.76
2	5.38	5.99	6.15	6.25	6.25
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	6.25	6.25	6.25
Total	9.07	10.30	16.86	17.06	17.26
Off-farm work (m/d)					
1	0	0	0	0	0
2	0	0	0	0	0
3	18.24	17.30	17.07	16.91	16.61
4	19.51	18.57	18.33	18.18	17.87
5	32.41	19.72	16.57	14.46	10.36
6	25.15	0	0	0	0
Total	95.31	55.59	51.97	49.55	44.84
Capital (Cr$)					
Operating	1,262	1,581	1,697	1,779	1,940
Investment	1,744	2,178	2,286	2,358	2,499
Credit limit	3,006	3,759	3,983	4,137	4,439

Medium Farm

Figure 10 shows efficiency frontiers C2 and D2, which consist of the exclusion of cotton from the entire farm and from the owner-operated part only, respectively, and the basic model frontier B2 for the medium farm. The numerical solutions are given in Tables 23, 24, 25, and 26. When cotton is removed entirely from the farm plans and, consequently, sharecropped land is used in alternative enterprises, the basic frontier B2 represents less risk at every income level. In addition, the risks associated with the medium farm plans for this situation are higher than those associated with small farms. As a result, it is unlikely that farm plans of frontier C2 would be chosen by medium farmers. Given a choice of these two alternative efficiency frontiers, medium farm decision-makers would obviously elect plans on efficiency frontier B2. When cotton is eliminated, the activities are essentially reduced to rice and cattle. The LP expected income is reduced from Cr$10,769 to Cr$7,705.

A comparison of resource use in frontier B2 with frontier C2 shows that the use of all resources are substantially decreased. Cropland "A" is exhausted at a higher income level, while cropland "B" is never restrictive along frontier C2. Actually, with negligible exceptions, cropland "B" is used only for forage. At the last feasible solution, .45 ha of fallow land is transformed into pasture land. With respect to labor and financial resources, much less is used at all income levels when compared to the basic model.

If cotton is removed from the owner-operated part of the farm only, there is a considerable risk-decreasing impact on all farm plans when

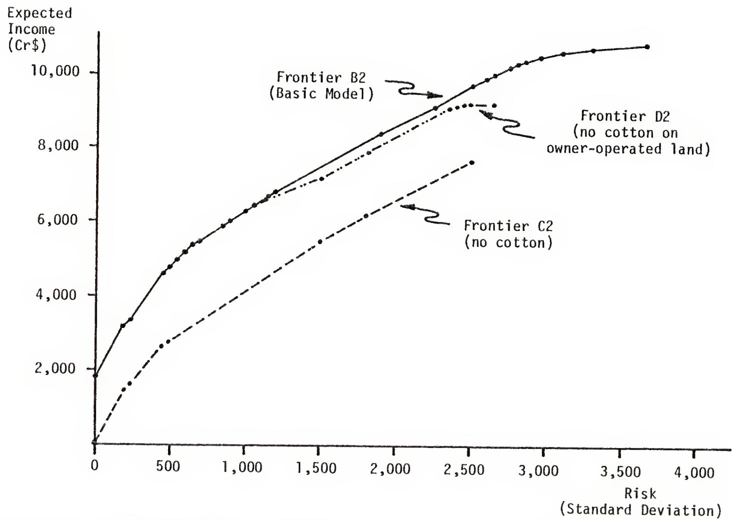

Figure 10. Medium farm efficiency frontiers B2, C2, and D2 (no cotton with and without sharecroppers) for minimum risk farm plans

Table 23. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier C2 (no cotton on the medium farm), by expected income level

Item and unit	Quadratic programming solutions						LP solution
	1	2	3	4	5	6	7
Expected income (Cr$)	1,500	1,600	2,700	2,800	5,500	6,200	7,705
Standard deviation (Cr$)	217	234	446	477	1,494	1,814	2,510
Coefficient of variation	.145	.146	.165	.170	.272	.292	.326
Cropping pattern							
Rice	0.84	0.88	1.62	1.68	1.73	1.73	1.73
Cassava (ha)	0.02	---	---	---	---	---	---
Beans/corn (ha)	---	---	---	0.04	---	---	---
Cattle (a-u)	0.06	0.23	0.80	1.03	12.16	15.24	21.85
Forage (ha)	0	0.01	0.04	0.06	0.73	0.91	1.31

Table 24. Resource requirements for selected farm plans on efficiency frontier C2 (no cotton on the medium farm), by expected income level

Item and unit	Selected farm plans						LP solution
	1	2	3	4	5	6	7
Expected income (Cr$)	1,500	1,600	2,700	2,800	5,500	6,200	7,705
Land (ha)							
Class "A"	0.84	0.88	1.62	1.72	1.73	1.73	1.73
Class "B"	0.02	0.01	0.05	0.06	0.73	0.91	1.31
Pasture	0.19	0.72	2.48	3.21	37.81	47.41	67.96
Fallow	0	0	0	0	0	0	0.45
Family labor (m/d)							
1	36.68	38.50	38.50	38.50	38.50	38.50	38.50
2	38.50	38.50	38.50	38.50	38.50	38.50	38.50
3	14.20	14.72	27.26	28.67	38.50	38.50	38.50
4	12.70	13.43	24.89	27.52	35.96	38.50	38.50
5	0.12	0.19	0.66	1.21	10.01	12.55	20.86
6							
Total	109.43	112.98	114.10	149.65	186.08	193.70	213.36
Temporary labor (m/d)							
1	0	0	0	0	8.89	10.79	14.86
2	0	0	0	2.99	11.12	12.73	16.17
3	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
Total	0	0	0	2.99	20.01	23.52	31.03
Permanent labor (m/d)							
1	0	0	32.21	35.30	35.30	35.30	35.30
2	0	1.71	35.30	35.30	35.30	35.30	35.30
3	0	0	0	0	0	2.54	7.98
4	0	0	0	0	0	0	5.44
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
Total	0	1.71	67.51	70.60	70.60	73.14	84.02
Capital (Cr$)							
Operating	24	87	660	783	4,507	5,549	7,810
Investment	27	100	345	446	5,251	6,586	9,440
Credit limit	51	187	1,013	1,229	9,758	12,135	17,250

Table 25. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier D2 (no cotton on owner-operated land, medium farm), by expected income level

Item and unit	Quadratic programming solutions					LP solution
	1	2	3	4	5	6
Expected income (Cr$)	6,200	7,200	7,900	9,100	9,200	9,232
Standard deviation (Cr$)	1,038	1,494	1,814	2,368	2,510	2,585
Coefficient of variation	.167	.208	.230	.260	.273	.280
Cropping pattern						
Owner-operated area:						
Rice (ha)	1.73	1.73	1.73	1.73	1.73	1.73
Beans (ha)	---	---	---	---	---	---
Beans/corn (ha)	---	---	---	---	---	---
Cattle (a-u)	7.64	12.16	15.24	20.51	21.85	22.56
Forage	0.46	0.73	0.91	1.23	1.31	1.35
Sharecropped area:						
Cassava (ha)	0.31	0.30	0.29	0.28	0.22	0.22
Cotton/beans/corn (ha)	21.39	20.50	19.91	18.82	15.08	15.08
No. of sharecroppers	2.17	2.08	2.02	1.91	1.53	1.53

Table 26. Resource requirements for selected farm plans on efficiency frontier C2 (no cotton for owner-operated land, medium farm), by expected income level

Item and unit	Selected farm plans					LP solution
	1	2	3	4	5	6
Expected income (Cr$)	6,200	7,200	7,900	9,100	9,200	9,232
Land (ha)						
Class "A"	1.73	1.73	1.73	1.73	1.73	1.73
Class "B"	22.17	21.53	21.10	20.35	16.53	16.63
Pasture	29.31	42.71	51.88	67.51	57.96	70.15
Fallow	0	0	0	0	0.45	2.64
Sharecropping	21.72	20.80	20.18	19.12	15.32	15.28
Family labor (m/d)						
1	38.50	38.50	38.50	38.50	38.50	38.50
2	38.50	38.50	38.50	38.50	38.50	38.50
3	34.78	38.50	38.50	38.50	38.50	38.50
4	32.24	35.96	38.50	38.50	38.50	38.50
5	38.50	38.50	38.50	38.50	38.50	38.50
6	38.50	38.50	38.50	38.50	38.50	38.50
Total	221.02	228.46	231.00	231.00	231.00	231.00
Temporary labor (m/d)						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
Total	0	0	0	0	0	0
Permanent labor (m/d)						
1	0	4.52	7.61	12.38	20.95	21.46
2	2.66	6.75	9.54	14.31	22.26	22.70
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	11.66	8.96	7.11	3.96	0	0
Total	14.32	20.23	24.25	31.15	43.21	44.16
Sharecropper labor (m/d)						
1	41.41	39.67	38.49	36.46	29.21	29.13
2	41.41	39.67	38.49	36.46	29.21	29.13
3	0	0	2.54	5.38	7.98	8.56
4	0	0	0	4.33	5.44	6.02
5	0	0	0	0	0	0
6	41.41	39.67	38.49	35.46	0	29.13
Total	124.23	119.01	118.01	120.59	71.84	101.96
Capital (Cr$)						
Operating	7,242	8,544	9,445	10,398	10,575	10,933
Investment	3,301	5,251	6,586	8,961	9,440	9,744
Credit limit	10,543	13,795	16,031	19,359	20,015	20,677

compared to the situation where no cotton at all is allowed. Indeed, there is little difference between frontier B2 and frontier D2 except that the LP expected income is reduced from Cr$10,769 in frontier B2 to Cr$9,232 in frontier D2, and a larger amount of sharecropper labor is employed in frontier D2 plans.

Large Farm

Next, a similar analysis was conducted for the large farm, where two efficiency frontiers were derived, one for the exclusion of cotton from the entire farm and the other for removing cotton only from the owner-operated part. In Figure 11, efficiency frontiers C3 and D3 may be compared with efficiency frontier B3, which refers to the basic model. The numerical results are given in Tables 27, 28, 29, and 30. A comparison of frontier B3 with frontier C3 shows that the basic model frontier represents less risk for each level of income. By removing cotton from the entire farm the standard deviation increases about Cr$2,000 to Cr$3,000 or more in relation to income level, and the LP income is reduced from Cr$20,685 to Cr$15,496. Effects of eliminating cotton from the owner-operated land only would be rather small.

By removing cotton from the entire farm the crop plan of the large farm is reduced to rice and cattle enterprises. Cropland "A" is used to cultivate rice and cropland "B" is used for cattle enterprises.

Labor requirements are basically met by family and permanent labor. With respect to financial resources, for comparable income levels, almost twice as much is used for farm plans along frontier C3, vis-a-vis those of the basic model frontier. As an example, the expected income level of Cr$15,496 for the LP solution requires Cr$61,996 of total

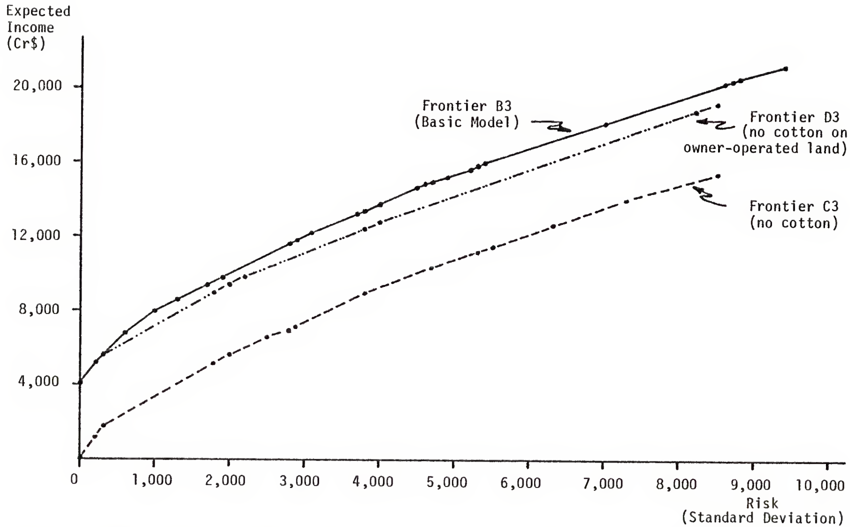

Figure 11. Large farm efficiency frontiers B3, C3, and D3 (no cotton with and without sharecroppers) for minimum risk farm plans

Table 27. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier C3 (no cotton on the large farm), by expected income level

Item and unit	Quadratic programming solutions								LP solution
	1	2	3	4	5	6	7	8	9
Expected income (Cr$)	6,600	7,200	8,900	9,300	10,400	11,200	12,600	14,000	15,496
Standard deviation (Cr$)	2,542	2,890	3,820	4,015	4,692	5,327	6,301	7,325	8,454
Coefficient of variation	.385	.401	.429	.432	.451	.476	.500	.523	.546
<u>Cropping pattern</u>									
Owner-operated area:									
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Cattle (a-u)	20.44	23.36	31.14	32.77	38.43	43.74	51.87	60.42	69.85
Forage (ha)	1.84	2.10	2.80	2.95	3.46	3.94	4.67	5.43	6.29

Table 28. Resource requirements for selected farm plans on efficiency frontier C3 (no cotton on the large farm), by expected income level

Item and unit	Selected farm plans								LP solution
	1	2	3	4	5	6	7	8	9
Expected income (Cr$)	6,600	7,200	8,900	9,300	10,400	11,200	12,600	14,000	15,496
Land (ha)									
Class "A"	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Class "B"	1.84	2.10	2.80	2.95	3.46	3.94	4.67	5.44	6.29
Pasture	72.16	82.47	109.94	115.69	135.68	154.40	183.11	213.29	246.56
Fallow	0	0	0	0	0	0	0	0	0
Family labor (m/d)									
1	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
2	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
3	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
4	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
5	21.60	24.68	32.90	32.90	32.90	32.90	32.90	32.90	32.90
6	30.63	32.90	32.90	32.90	32.90	32.90	32.90	32.90	32.90
Total	183.83	189.18	197.40	197.40	197.40	197.40	197.40	197.40	197.40
Temporary labor (m/d)									
1	0	2.47	9.06	10.44	15.24	19.74	26.62	33.87	41.85
2	0	0	5.07	6.13	9.82	13.28	18.58	24.14	30.28
3	0	0	0	0	0	0	8.59	17.62	27.58
4	0	0	0	0	0	0	7.02	16.05	26.01
5	0	0	0	0	0	0	0	0	9.96
6	0	0	0	0	0	0	0	9.03	18.99
Total	0	2.47	14.13	16.57	25.06	33.02	60.81	100.71	154.67
Permanent labor (m/d)									
1	30.93	30.93	30.93	30.93	30.91	30.93	30.93	30.93	30.93
2	29.03	30.93	30.93	30.93	30.93	30.93	30.93	30.93	30.93
3	6.32	9.40	17.62	19.34	25.32	30.93	30.93	30.93	30.93
4	4.74	7.83	16.05	17.77	23.75	29.36	30.93	30.93	30.93
5	0	0	0	1.72	7.70	13.31	21.90	30.93	30.93
6	0	0.81	9.03	10.75	16.73	22.34	30.93	30.93	30.93
Total	71.02	79.90	104.56	111.44	135.36	157.80	176.55	185.58	185.58
Capital (Cr$)									
Operating I	8,199	9,379	12,567	13,245	15,600	15,600	15,600	15,600	15,600
Investment I	9,731	11,120	14,824	15,600	15,600	15,600	15,600	15,600	15,600
Operating II	0	0	0	0	0	2,207	5,606	9,189	13,149
Investment II	0	0	0	0	2,695	5,220	9,092	13,161	17,647
Credit limit	17,930	20,499	27,391	28,845	33,895	38,627	45,898	53,550	61,996

Table 29. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier D3 (no cotton on owner-operated land, large farm), by expected income level

Item and unit	Quadratic programming solutions					LP solution
	1	2	3	4	5	6
Expected income (Cr$)	5,800	9,000	9,800	12,800	18,800	19,255
Standard deviation (Cr$)	280	1,830	2,243	4,015	8,158	8,454
Coefficient of variation	.048	.203	.229	.314	.434	.439
Cropping pattern						
Owner-operated area:						
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07
Beans (ha)						
Beans/corn (ha)						
Cattle (a-u)	0.17	14.46	17.93	32.77	67.37	69.85
Forage (ha)	0.01	1.30	1.61	2.95	6.06	6.29
Sharecropped area:						
Cassava (ha)	0.77	0.71	0.64	0.58	0.54	0.53
Cotton/beans/corn (ha)	52.13	48.49	43.26	39.62	36.56	36.27
No. of sharecroppers	5.29	4.92	4.39	4.02	3.71	3.68

Table 30. Resource requirements for selected farm plans on efficiency frontier D3 (no cotton on owner-operated land, large farm), by expected income level

Item and unit	Selected farm plans					LP solution
	1	2	3	4	5	6
Expected income (Cr$)	5,800	9,000	9,300	12,800	18,800	19,255
Land (ha)						
Class "A"	1.07	1.07	1.07	1.07	1.07	1.07
Class "B"	52.90	50.49	45.53	43.13	43.13	43.13
Pasture	10.36	58.41	65.70	115.69	237.80	246.56
Fallow	0	0	0	0	0	0
Sharecropping	52.88	49.19	43.92	40.18	37.07	36.84
Family labor (m/d)						
1	32.90	32.90	32.90	32.90	32.90	32.90
2	32.90	32.90	32.90	32.90	32.90	32.90
3	17.80	32.90	32.90	32.90	32.90	32.90
4	15.23	31.33	32.90	32.90	32.90	32.90
5	32.90	32.90	32.90	32.90	32.90	32.90
6	32.90	32.90	32.90	32.90	32.90	32.90
Total	165.63	195.83	197.40	197.40	197.40	197.40
Temporary labor (m/d)						
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
Total	0	0	0	0	0	0
Permanent labor (m/d)						
1	0	0	0	0	0	2.52
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	0	0	0	0
6	0	0	0	0	0	0
Total	0	0	0	0	0	2.52
Sharecropper labor (m/d)						
1	13.76	25.86	28.80	41.38	70.68	70.25
2	15.82	25.13	27.39	37.06	59.60	61.22
3	0	0	3.66	19.34	55.90	58.51
4	0	0	2.09	17.77	54.32	56.94
5	24.03	25.17	0	1.72	38.27	40.89
6	100.85	85.31	25.70	10.75	47.30	49.92
Total	154.46	161.47	84.64	128.32	326.07	337.74
Capital (Cr$)						
Operating I	10,852	15,600	15,600	15,600	15,600	15,600
Investment I	80	6,884	8,534	15,600	15,600	15,600
Operating II	0	0	0	5,081	18,428	19,388
Investment II	0	0	0	0	16,470	17,647
Credit limit	10,932	22,484	24,134	36,281	66,098	68,235

financial resources, while the expected income level of Cr$15,261 in the basic model requires only Cr$38,586 of total financial resources. In addition, because of higher quantities of cattle activities entering the solutions at lower expected income levels, larger amounts of investment capital are used.

When cotton is permitted on sharecropper units, frontier D3, but not on the owner-operated land, cropland "B", used for cotton activities on the owner-operated part of the farm in the basic model, is shifted to sharecropping. At low income levels pasture land is transformed into cropland "B" and, subsequently, is used in the sharecropping part of the farm. Gradually, as more animal-units are introduced into the farm plans, less pasture land is transformed into cropland "B". With respect to labor, the farm plans of frontier D3 rely basically on family and sharecropper labor. No temporary labor is hired and, except for period 1 in the last feasible solution, no permanent labor is used in farm plans on frontier D3. Financial resources come into the solutions at lower income levels than in comparable farm plans of frontiers B3 and C3. This is so because less temporary and permanent labor is used. In addition, investment capital is also employed at lower amounts because less animal-units come into the solutions at lower income levels.

From the results discussed above, it can be concluded that, given the existing enterprise alternatives to cotton, the exclusion of cotton from the farm plans would mean less intensive levels of land use and farmers would experience less income at given levels of risk.

Effects of a Change in the Price of Cotton

Cotton, like most agricultural commodities, is characterized by quality differences which provide a basis for separating it into grades. Each of these grades ordinarily brings a different price and may require different production costs. The fact that prices and production costs differ for different cotton grades means that additional decisions are required. Minimum prices for cotton have been set on the basis of staple length. The length for mocó varies between 32 and 38 mm, while other types have a length of 28 to 30 mm [Soares, 1977]. However, according to information received by the author during a visit to two cotton mills (usinas) in Parelhas and Umarizal, which are among the major processors of cotton produced in the Seridó Region, the native mocó, which is predominantly grown in the region, has suffered crossbreeding with lower grade cotton.[2] As a result, most cotton grown in the region tends to fall below the 32 to 38 mm fiber length. Because of this trend and the oligopsonistic nature of the transactions between cotton growers and mills, no price differentiation has been observed.

Table 31 presents the minimum prices for cotton grown in Northeastern Brazil. These price differences represent an attempt by the federal government to stimulate the creation of an effective grading system and to induce farmers to increase total cotton production. In addition, its purpose is to induce farmers to grow relatively more mocó that is free of crossbreeding with lower grade cotton.

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[2]This development has also been observed in the state of Ceará and is reported in the Quixadá study [Soares, 1977].

Table 31. Minimum prices for cotton, Northeast Brazil, 1977

Staple length (millimeters)	Price/kg (cruzeiros)	Increase (percent)
28 to 34	5.32	---
32 to 34	6.00	12.8
36 to 38	8.08	34.7

SOURCE: Soares [1977, p. 132].

In order to evaluate the impact of a higher price for cotton on farming systems in the Seridó Region, an increase of 15 percent in the price of mocó cotton was simulated. The rationale for this procedure is the same as the one presented in the Quixadá study, where the price increase is a little higher than the difference between the minimum prices set for 32 to 34 and 28 to 30 mm cotton, but is lower than the difference between the 36 to 38 and 32 to 24 mm cotton. In addition, the increase is limited to 15 percent of the mocó price because of the high degree of hybridization [Soares, 1977].

Three new efficiency frontiers were derived, one for each farm size. This was done by adjusting the annual time series of gross returns for single and mixed-cropping cotton. Annual prices of cotton were increased by 15 percent and deflated by the domestic price index. Next, new gross margins and gross returns for cotton were calculated so that the new variance-covariance matrix of enterprise gross returns could be obtained.

Small Farm

Figure 12 shows the new efficiency frontier E1 based on an increase in cotton price and the basic model frontier B1 for the small farm. The numerical solutions are given in Tables 32 and 33. Up to the expected income level of Cr$5,160, the difference is negligible and after this expected income level, the difference is very small. Thus, the proposed increase in cotton price would have very little effect on income level, risk, and resource employment on the small farm. The explanation for these results is the limited resources available to the small farm, especially land. At the low income solutions, small farmers' best

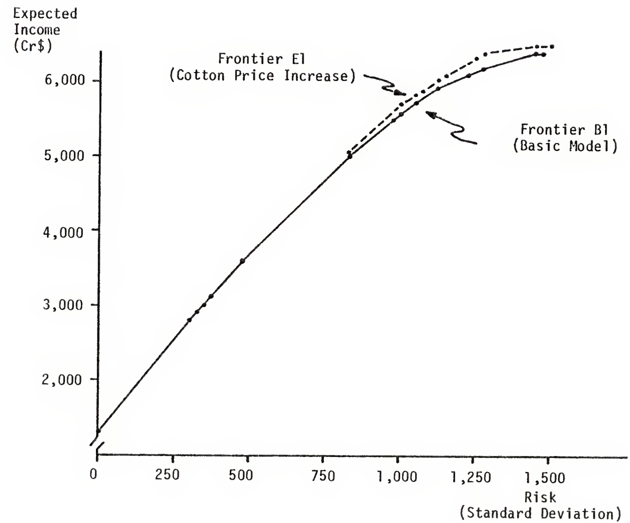

Figure 12. Small farm efficiency frontiers B1 and E1 (cotton price increase) for minimum risk farm plans

Table 32. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier El (cotton price increase on the small farm), by expected income level

Item and unit	Quadratic programming solutions						LP solution
	1	2	3	4	5	6	7
Expected income (Cr$)	5,160	5,700	5,800	6,000	6,100	6,400	6,540
Standard deviation (cr$)	857	1,005	1,055	1,126	1,159	1,305	1,492
Coefficient of variations	.166	.176	.182	.188	.190	.204	.228
Cropping pattern							
Cotton (ha)	0.47	1.70	1.67	1.64	1.62	1.56	---
Rice (ha)	0,86	0.86	0.86	0.86	0.86	0.86	0.86
Cotton/beans/corn (ha)	---	0.60	0.64	0.70	0.75	1.19	2.75
Cotton/beans (ha)	0.19	0.45	0.44	0.41	0.37	---	---
Cattle (a-u)	9.91	9.91	10.86	11.77	12.25	14.20	14.20

Table 33. Resource requirements for selected farm plans on efficiency frontier E1 (cotton price increase on the small farm), by expected income level

Item and unit	Selected farm plans						LP solution
	1	2	3	4	5	6	7
Expected income (Cr$)	5,160	5,700	5,800	6,000	6,100	6,400	6,540
Land (ha)							
Class "A"	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Class "B"	0.99	2.75	2.75	2.75	2.75	2.75	2.75
Pasture	7.43	7.43	8.01	8.83	9.19	10.65	10.65
Fallow	0	0	0.58	1.40	1.76	3.22	3.22
Family labor (m/d)							
1	36.17	36.17	36.17	36.17	36.17	36.17	36.17
2	36.17	36.17	36.17	36.17	36.17	36.17	36.17
3	24.86	35.77	36.17	36.17	36.17	36.17	36.17
4	20.05	24.21	24.66	25.26	25.55	26.98	34.47
5	11.07	24.17	28.13	33.72	36.17	36.17	36.17
6	15.54	23.38	31.27	36.17	36.17	36.17	36.17
Total	143.86	179.87	192.57	203.66	260.40	207.83	215.32
Temporary labor (m/d)							
1	0.09	3.07	3.43	3.90	4.14	5.56	12.73
2	16.70	41.11	41.86	42.72	43.17	45.54	72.36
3	0	0	0	0	0	0	0.68
4	0	0	0	0	0	0	0
5	0	0	0	0	0	3.65	2.78
6	0	0	0	0	4.88	24.68	25.24
Total	16.70	44.18	45.29	46.62	52.19	79.41	111.79
Permanent labor (m/d)							
1	6.25	6.25	6.25	6.25	6.25	6.25	6.25
2	6.25	6.25	6.25	6.25	6.25	6.25	6.25
3	0	0	0	0.52	0.74	1.68	6.25
4	0	0	0	0	0	0	0
5	0	0	0	0	0	6.25	6.25
6	0	0	0	6.25	6.25	6.25	6.25
Total	12.50	12.50	12.50	19.27	19.49	26.68	31.25
Off-farm work (m/d)							
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	11.31	0.40	0	0	0	0	0
4	16.12	11.96	11.51	10.91	10.62	9.19	1.70
5	25.10	12.00	8.04	2.45	0	0	0
6	20.63	12.79	4.90	0	0	0	0
Total	73.16	37.15	24.45	13.36	10.62	9.19	1.70
Capital (Cr$)							
Operating	1,402	1,596	1,701	1,889	1,989	2,468	2,740
Investment	1.744	1.744	1,880	2,072	2,157	2,499	2,499
Credit limit	3,146	3,340	3,581	3,961	4,146	4,967	5,239

alternative would be to work outside the farm for wages. This explains why both efficiency frontiers, B1 and E1, coincide up to the expected income level of Cr$5,160. Above this point, the amount of land available to farmers is too small to permit significant improvement in their expected income levels.

Medium Farm

The efficiency frontier E2, derived for the medium farm, lies above the basic model frontier B2 in its entirety (Figure 13). The numerical solutions are given in Tables 34 and 35. The change in cotton price would have a much higher risk-reducing or income-increasing impact on income for the medium farm than on the small farm. The comparison of the results of a 15 percent increase in the price of cotton with the solutions of the basic model frontier indicates that the medium farmer would allocate more land to sharecroppers rather than increase his own cotton enterprises. The number of sharecroppers observed on the farm plans of frontier E2 is higher for every comparable expected income level. On the other hand, the new cotton price does not appear to induce medium farmers to increase their owner-operated area allocated to cotton production. As the results indicate, there is a reduction in cotton area. A possible reason for this is that the medium landowner can obtain higher levels of income by using less land on his owner-operated part of the farm and allocating additional land to sharecroppers. In other words, the medium farmer can achieve any given level of income with less risk by using more sharecroppers.

The major difference between the resource pattern in the two frontiers is a greater utilization of sharecroppers in the landowner's

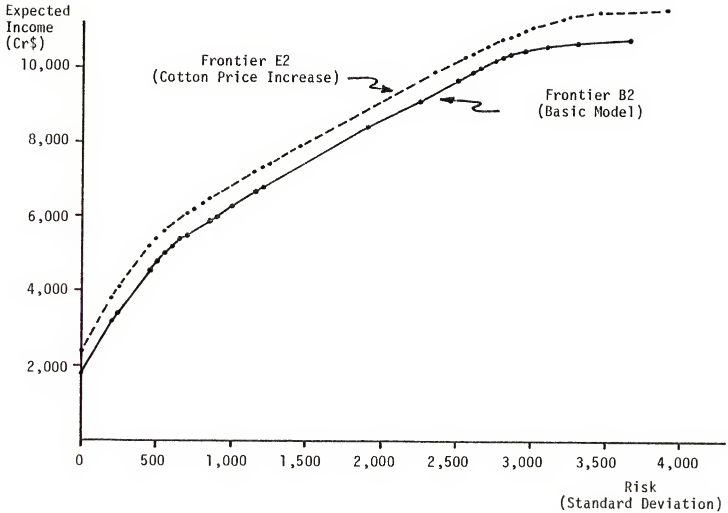

Figure 13. Medium farm efficiency frontiers B2 and E2 (cotton price increase) for minimum risk farm plans

Table 34. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier E2 (cotton price increase on the medium farm), by expected income level

Item and unit	Quadratic programming solutions								LP solution
	1	2	3	4	5	6	7	8	9
Expected income (Cr$)	2,400	3,900	5,400	6,400	7,400	9,800	10,400	11,400	11,638
Standard deviation (Cr$)	0	214	504	825	1,240	2,334	2,594	3,232	3,893
Coefficient of variation	---	.055	.093	.129	.168	.238	.249	.284	.334
Cropping pattern									
Owner-operated area:									
Cotton (ha)	0	0.16	0.51	0.82	1.21	1.78	1.60	6.18	13.71
Rice (ha)	0	0.82	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Cotton/beans/corn (ha)	---	---	0.02	0.40	0.76	1.65	1.98	2.94	---
Cotton/beans (ha)	---	---	---	0.14	0.25	0.39	0.10	---	---
Cattle (a-u)	0	0	0.88	4.29	8.05	17.72	20.28	21.71	21.71
Forage (ha)	---	---	0.05	0.26	0.48	1.06	1.22	1.30	1.30
Sharecropper area:									
Cassava (ha)	0.38	0.37	0.35	0.32	0.36	0.24	0.23	0.09	0.02
Cotton/beans/corn (ha)	26.02	25.13	23.65	21.88	24.34	16.16	15.97	6.11	1.58
No. of sharecroppers	2.64	2.55	2.40	2.22	2.47	1.64	1.02	0.62	0.16

Table 35. Resource requirements for selected farm plans on efficiency frontier E2 (cotton price increase on the medium farm), by expected income level

Item and unit	Selected farm plans				
	1	2	3	4	5
Expected income (Cr$)	2,400	3,900	5,400	6,400	7,400
Land (ha)					
Class "A"	0	0.82	1.73	1.73	1.73
Class "B"	26.36	25.63	24.63	23.84	27.42
Pasture	9.73	9.01	10.73	20.56	35.82
Fallow	0	0	0	0	0
Sharecropping	26.36	25.47	24.04	22.22	24.72
Family labor (m/d)					
1	0.06	35.55	38.50	38.50	38.50
2	0.06	38.50	38.50	38.50	38.50
3	0.02	14.26	32.08	38.50	38.50
4	0.02	12.41	27.38	33.40	38.50
5	38.50	38.50	38.50	38.50	38.50
6	38.50	38.50	38.50	38.50	38.50
Total	77.16	177.72	213.46	255.30	231.00
Temporary labor (m/d)					
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	47.83
Total	0	0	0	0	47.83
Permanent labor (m/d)					
1	0	0	0	0	0
2	0	0	0	21.27	33.99
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	35.30	35.30	35.30	35.30	35.30
Total	35.30	35.30	35.30	56.57	69.29
Sharecropper labor (m/d)					
1	0	0	37.67	42.37	47.14
2	0	0	45.85	42.37	47.14
3	0	0	0	2.43	11.53
4	0	0	0	0	1.05
5	18.03	15.03	12.75	17.01	47.14
6	50.27	48.58	45.95	42.37	47.14
Total	68.30	63.61	142.12	146.55	201.14
Capital (Cr$)					
Operating	5,564	5,376	5,700	6,062	8,937
Investment	0	0	380	1,855	3,477
Credit limit	5,564	6,376	6,080	7,917	12,414

Table 35. Continued

Item and unit	Selected farm plans			LP solution
	6	7	8	9
Expected income (Cr$)	9,800	10,400	11,400	11,637
Land (ha)				
Class "A"	1.73	1.73	1.73	1.73
Class "B"	21.32	21.07	16.63	16.63
Pasture	59.79	67.51	67.51	67.51
Fallow	0	0	0	0
Sharecropping	16.43	16.18	6.21	1.62
Family labor (m/d)				
1	38.50	38.50	38.50	38.50
2	38.50	38.50	38.50	38.50
3	38.50	38.50	38.50	38.50
4	38.50	38.50	38.50	38.50
5	38.50	38.50	38.50	38.50
6	38.50	38.50	38.50	38.50
Total	231.00	231.00	231.00	231.00
Temporary labor (m/d)				
1	0	0	21.72	19.64
2	51.57	53.38	137.50	137.50
3	0	0	18.03	40.77
4	0	0	0	0
5	0	0	0	45.32
6	1.19	0	0	15.09
Total	52.76	53.38	117.25	258.32
Permanent labor (m/d)				
1	27.20	29.85	35.30	35.30
2	35.30	35.30	35.30	35.30
3	0	1.96	35.30	35.30
4	0	0	17.50	17.18
5	0	0	35.30	35.30
6	35.30	35.30	22.78	35.30
Total	97.80	102.41	181.48	193.68
Sharecropper labor (m/d)				
1	31.34	30.84	11.34	3.08
2	31.34	30.84	11.34	3.08
3	31.34	30.84	11.34	3.08
4	31.34	30.84	11.34	3.08
5	31.34	30.84	11.34	3.08
6	31.34	30.84	11.34	3.08
Total	172.27	172.21	68.04	18.48
Capital (Cr$)				
Operating	10,561	11,373	10,854	10,399
Investment	7,654	8,761	9,378	9,373
Credit limit	18,215	20,232	20,232	19,777

operated part of the farm. This increase was expected since the increase in number of sharecroppers made more sharecropper labor available to the landowner. With respect to land use, more pasture land is transformed into cropland "B" and made available for sharecroppers.

Large Farm

The new efficiency frontier E3, resulting from an increase of 15 percent in the price of cotton for the large farm, lies above the basic model frontier at all points (Figure 14). The numerical solutions for frontier E3 are given in Tables 36 and 37. In comparison with the previous analysis of the medium farm, an increase in the price of cotton for the large farm would have a much higher risk-reducing impact on income. Large farmers can obtain similar levels of income at much lower risk than other farm sizes. The large farmer can obtain an income level of Cr$21,700 with less risk with a 15 percent increase in the price of cotton, than with the Cr$20,255 plan in the basic model. In this way the large landowner could increase his income by about 7 percent with less risk. Except for the profit maximizing (LP) plan, which, like the basic model, has two sharecroppers, the number of sharecroppers is much higher along all farm plans of frontier E3 compared to the basic frontier B3. Thus, with an increase in the price of cotton, it would pay the large farmer to allocate more cropland "B" to sharecroppers than to increase his own cotton enterprise. In the same way as for the medium farm, an increase of 15 percent in cotton price does not induce the farmer to increase his cropland allocated to cotton. Instead, he would choose to reduce his own production and increase the area allocated to sharecroppers.

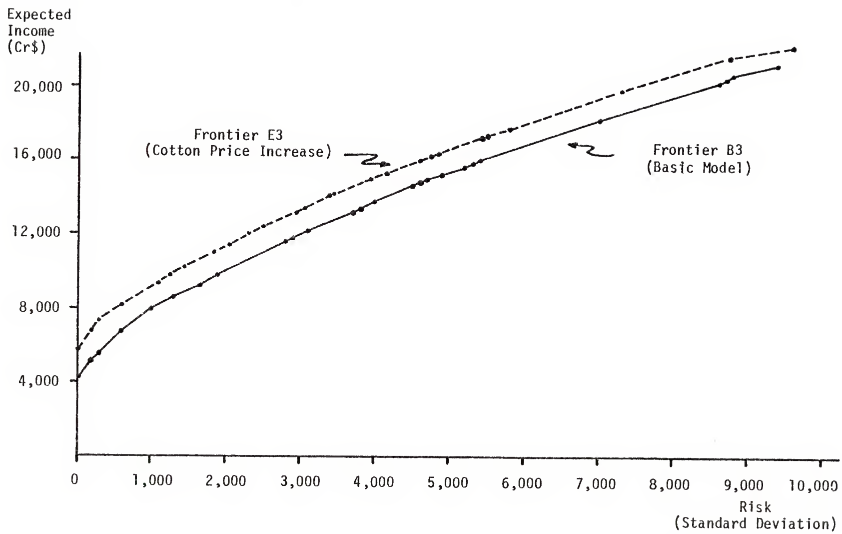

Figure 14. Large farm efficiency frontiers B3 and E3 (cotton price increase) for minimum risk farm plans

Table 36. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier E3 (cotton price increase on the large farm), by expected income level

Item and unit	Quadratic programming solutions									LP solution
	1	2	3	4	5	6	7	8	9	10
Expected income (Cr$)	7,400	9,400	11,500	13,400	15,300	17,400	19,800	21,600	21,700	22,177
Standard deviation (Cr$)	303	1,081	2,069	3,051	4,135	5,517	7,383	8,733	8,850	9,591
Coefficient of variation	.041	.115	.180	.228	.270	.317	.373	.404	.408	.432
Cropping pattern										
Owner-operated area:										
Cotton (ha)	0.35	2.00	2.89	4.89	4.83	5.04	3.36	2.18	3.42	15.02
Rice (ha)	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
Cotton/beans/corn (ha)	0.01	0.94	1.81	2.91	3.83	4.87	5.01	5.06	4.52	---
Cotton/beans (ha)	---	0.74	0.74	1.11	0.54	---	---	---	---	---
Cattle (a-u)	0.30	5.28	12.99	18.89	28.28	39.75	56.99	59.19	69.85	69.85
Forage (ha)	0.03	0.48	1.17	2.54	3.58	5.13	6.23	6.29	6.29	6.29
Sharecropped area:										
Cassava (ha)	0.80	0.71	0.64	0.51	0.47	0.45	0.45	0.44	0.42	0.32
Cotton/beans/corn (ha)	54.30	48.09	43.76	34.39	32.03	30.65	30.35	29.66	28.48	21.48
No. of sharecroppers	5.51	4.88	4.44	3.49	3.25	3.11	3.08	3.01	2.89	2.18

Table 37. Resource requirements for selected farm plans on efficiency frontier E3 (cotton price increase on the large farm), by expected income level

Item and unit	Selected farm plans				
	1	2	3	4	5
Expected income (Cr$	7,400	9,400	11,500	13,400	15,300
Land (ha)					
Class "A"	1.07	1.07	1.07	1.07	1.07
Class "B"	55.52	52.99	51.07	45.50	44.26
Pasture	13.47	28.50	53.78	69.05	100.97
Fallow	0	0	0	0	0
Sharecropping	55.13	48.82	44.46	34.39	32.52
Family labor (m/d)					
1	32.92	32.90	32.90	32.90	32.90
2	32.90	32.90	32.90	32.90	32.90
3	19.89	32.90	32.90	32.90	32.90
4	16.83	12.90	32.90	32.90	32.90
5	32.90	32.90	32.90	32.90	32.90
6	32.90	32.90	32.90	32.90	32.90
Total	168.32	197.40	197.40	197.40	197.40
Temporary labor (m/d)					
1	0	0	0	0	0
2	0	0	0	77.94	98.46
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
Total	0	0	0	77.94	98.46
Permanent labor (m/d)					
1	0	0	0	0	0
2	0	0	30.93	30.93	30.93
3	0	0	0	0	15.12
4	0	0	0	0	0
5	0	0	0	0	9.19
6	30.93	30.93	30.93	0	0
Total	30.93	30.93	61.86	30.93	55.24
Sharecropper labor (m/d)					
1	14.14	26.65	38.19	51.30	62.01
2	19.45	79.78	84.78	66.54	62.01
3	0	15.13	35.35	64.55	62.01
4	0	0	14.22	30.88	43.39
5	42.20	57.14	67.07	56.54	62.01
6	105.13	93.12	84.78	66.54	62.01
Total	180.92	271.82	324.39	346.35	353.44
Capital (Cr$)					
Operating I	11,634	12,679	15,163	15,600	15,500
Operating II	0	0	0	412	3,843
Investment I	145	2,515	6,182	8,991	13,462
Investment II	0	0	0	0	0
Credit limit	11,778	15,194	21,345	25,003	32,905

Table 37. Continued

Item and unit	Selected farm plans			LP solution
	6	7	8	9
Expected income (Cr$)	17,400	19,300	21,500	22,177
Land (ha)				
Class "A"	1.07	1.07	1.07	1.07
Class "B"	44.58	44.33	43.59	43.13
Pasture	141.79	202.39	244.72	246.56
Fallow	0	0	0	0
Sharecropping	31.09	30.83	30.13	21.33
Family labor (m/d)				
1	32.90	32.90	32.90	32.90
2	32.90	32.90	32.90	32.90
3	32.90	32.90	32.90	32.90
4	32.90	32.90	32.90	32.90
5	32.90	32.90	32.90	32.90
6	32.90	32.30	32.90	32.90
Total	137.40	137.40	137.40	137.40
Temporary labor (m/d)				
1	0	0	11.28	8.93
2	125.00	125.00	125.00	125.00
3	4.42	15.53	34.03	54.03
4	0	0	0	0.75
5	0	5.40	6.76	82.60
6	0	0	0	42.53
Total	129.42	145.93	167.12	323.34
Permanent labor (m/d)				
1	16.11	30.93	30.93	30.93
2	30.93	30.93	30.93	30.93
3	30.93	30.93	30.93	30.93
4	0	17.56	30.93	30.93
5	30.93	30.93	30.93	30.93
6	22.07	30.93	30.93	30.93
Total	130.97	172.21	185.58	185.58
Sharecropper labor (m/d)				
1	59.28	58.30	57.45	41.63
2	59.28	58.30	57.45	41.63
3	59.28	58.30	57.45	41.63
4	59.28	58.30	57.45	41.63
5	59.28	58.30	57.45	41.63
6	59.28	58.30	57.45	41.63
Total	355.68	352.30	344.70	249.78
Capital (Cr$)				
Operating I	15,600	15,600	15,600	15,600
Operating II	8,509	15,467	20,163	19,525
Investment I	15,600	15,600	15,600	15,600
Investment II	3,321	11,539	17,336	17,547
Credit limit	43,130	58,196	68,599	68,372

The major effect of the cotton price change on resource use would be an increase in the use of sharecropper labor. With respect to land use, pasture is transformed into cropland "B" and subsequently allocated for sharecroppers in farm plans associated with low income levels. As income levels increase, more cattle enterprises are brought into the solutions and less pasture land is allocated to sharecroppers. Comparable to the basic model and to other farm sizes, the farm plans of frontier E3 use more land. The greater utilization of land is related to the increase in the number of sharecroppers.

In conclusion, the results show that a 15 percent increase in cotton price would have a risk-reducing impact on income. With higher cotton prices, farmers can obtain not only similar levels of income at lower risk but also higher income levels without having to face coefficients of variation greater than those of the basic model. However, the risk-reducing impact on income will be considerably more for large farmers than for small farmers. In other words, the larger the farm, the greater will be the risk-reducing impact on income. Also, the change in price would induce an increase in the number of sharecroppers.

Effects of a Reduction in Credit Availability

Agricultural credit has been one of the major instruments of economic policy in promoting and accelerating agricultural development in Brazil. Among alternative sources of external financial funds for farmers in the Seridó Region, bank credit ranks as the most important. In the sample data the major bank source was the Banco do Brasil S.A. with 95 percent of all bank loans. For farmers, bank loans may be categorized in two types, operating capital and investment capital. Agricultural credit policy in Brazil has been characterized by an

abundant supply of loans in the last two decades [Patrick, 1972]. During the survey, credit policy was still very liberal. However, the policy has been strongly criticized in recent years for the way it has been implemented. It has been argued that the credit policy has favored large farms with respect to bank loans, while small farms were neglected. According to census data for 1970, small farmers (less than 10 ha) received only 5.5 percent of all bank loans in Brazil [Ferreira, 1977]. In addition, because of high inflation rates in Brazil, farmers have been paying negative interest rates for bank loans in real terms. As a result, large farmers have been removing their own operating and investment capital from agriculture and substituting bank loans [Soares, 1976]. As a reaction to these criticisms and other economic pressures, credit supplies currently are being curtailed. Thus, less institutional credit may be available to farmers. Since most of the credit in the Seridó Region is used to cover the owner's operating costs and sharecropping production, it is important to evaluate possible effects on farmer behavior as a result of a reduction in credit availability. To accomplish this objective the analysis reported in this section tests the sensitivity of restricting the amount of credit made available to farmers. Since sharecroppers have little access to institutional credit, they must rely almost exclusively on their landlords for operating capital. Thus, by reducing the amount of credit available to landowners, the supply of operating capital for sharecroppers would be affected also.

The results of the basic model frontiers in Chapter IV show that, for all three farm sizes, financial resources never become restrictive. In part, these results may reflect the government credit policy in effect during the period when the survey was conducted. However, it may

also reflect a general tendency of farmers to over estimate land values on surveys with the fear of land expropriation.[3] Therefore, two new efficiency frontiers were derived for each farm size. Credit availability was reduced by 50 percent and by 75 percent for each farm size. A reduction of 50 percent in credit availability would affect only the large farm, while no change would occur in the efficiency fronter derived for the small and medium farms. However, a reduction of 75 percent would affect all farm sizes.

Small Farm

The frontier F1, where credit to the small farm was reduced by 75 percent, and the basic model frontier B1 are given in Figure 15. The numerical results are given in Tables 38 and 39. Frontier F1 lies below the basic model frontier B1, once credit becomes a limiting factor, after the Cr$5,900 level of expected income. The implication of a reduction of 75 percent in credit available to the small farm is an increase in risk at the higher income levels because the credit constraint forces the small farmer to use riskier enterprises to obtain a given level of income. For example, in the basic model frontier B1, a farm plan at the Cr$6,245 level of expected income has a coefficient of variation of .202. If credit supply is reduced by 75 percent, it would not be possible to achieve a similar level of income with a .202 coefficient of variation. At the Cr$6,100 level of expected income, the coefficient of variation is 10 percent greater than in the basic model.

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[3]As explained in Chapter III, capital restrictions were specified basically on borrowing capacity of farmers. The overall credit limit was specified as 80 percent of the value of land assets.

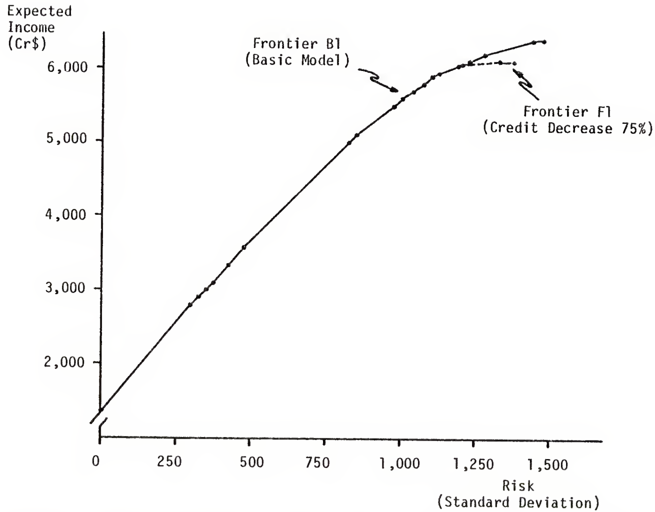

Figure 15. Small farm efficiency frontier B1 and F1 (credit decrease of 75 percent) for minimum risk farm plans

Table 38. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier F1 (credit reduction of 75 percent on the small farm), by expected income level

Item and unit	Quadratic programming solutions			LP solution
	1	2	3	4
Expected income (Cr$)	5,900	6,050	6,100	6,101
Standard deviation (Cr$)	1,132	1,182	1,325	1,376
Coefficient of variation	.192	.195	.217	.256
Cropping pattern				
Owner-operated area:				
Cotton (ha)	1.69	1.65	0.30	---
Rice (ha)	0.86	0.86	0.86	0.86
Cotton/beans/corn (ha)	0.74	0.77	2.45	2.75
Cotton/beans (ha)	0.33	0.32	---	---
Cattle (a-u)	12.25	13.00	12.41	12.27

Table 39. Resource requirements for selected farm plans on efficiency frontier F1 (credit reduction of 75 percent on the small farm), by expected income level

Item and unit	Selected farm plans			LP solution
	1	2	3	4
Expected income (Cr$)	5,900	6,050	6,100	6,101
Land (ha)				
Class "A"	0.86	0.86	0.86	0.86
Class "B"	2.75	2.75	2.75	2.75
Pasture	9.19	9.75	9.31	8.38
Fallow	1.76	0.90	1.34	1.77
Family labor (m/d)				
1	36.17	36.17	36.17	36.17
2	36.17	36.17	36.17	36.17
3	36.17	36.17	36.17	36.17
4	36.17	36.17	36.17	36.17
5	25.29	25.74	32.33	33.73
6	36.17	36.17	36.17	36.17
Total	206.14	206.59	213.18	214.58
Temporary labor (m/d)				
1	3.93	4.78	10.39	12.25
2	42.19	42.35	66.70	71.88
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	4.30	12.48	6.90	5.56
Total	50.32	60.21	84.49	89.69
Permanent labor (m/d)				
1	6.25	6.25	6.25	6.25
2	6.25	6.25	6.25	6.25
3	0.53	0.33	5.23	6.20
4	0	0	0	0
5	0	0	0	0
6	6.25	6.25	6.25	6.25
Total	19.28	23.53	23.98	24.95
Off-farm work (m/d)				
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	10.38	10.43	3.34	2.44
5	0	0	0	0
6	0	0	0	0
Total	10.33	10.43	3.34	2.44
Capital (Cr$)				
Operating	1,978	2,160	2,266	2,290
Investment	2,156	2,288	2,184	2,159
Credit limit	4,134	4,448	4,449	4,449

In the F1 frontier compared to the basic model, B1, the major change in production is a substitution of cotton/beans/corn for cotton and a slight reduction in cattle. Also, family labor would increase its off-farm work in period 4.

In summary, the effects of a 75 percent credit reduction, from the restriction used in this study, probably would have relatively small effects on resource use, output, resource employment, and incomes on the small farm.

Medium Farm

In Figure 16 the new efficiency frontier F2, where a 75 percent reduction in credit is simulated for the medium farm, may be compared with the basic model frontier B2. The numerical solutions in frontier F2 are given in Tables 40 and 41. The new frontier derived for the medium farm lies below the basic model frontier B2, where credit becomes a limiting factor at the Cr$6,800 level of expected income. In the basic model frontier the farm plan at the Cr$9,063 level of expected income has a coefficient of variation of .247 and a standard deviation of Cr$2,242. If credit supplies were reduced by 75 percent, the maximum expected income would be Cr$9,007 (LP solution) with a coefficient of variation of .329 and a standard deviation of Cr$2,961. The maximum expected income in the B2 frontier is Cr$10,769. These results imply a significant increase in risk or reduction in expected income and indicates the importance of credit as a way of reducing the risk impact on medium farms.

To achieve income levels higher than Cr$6,800, their enterprise combinations would have to be changed. The major changes observed in

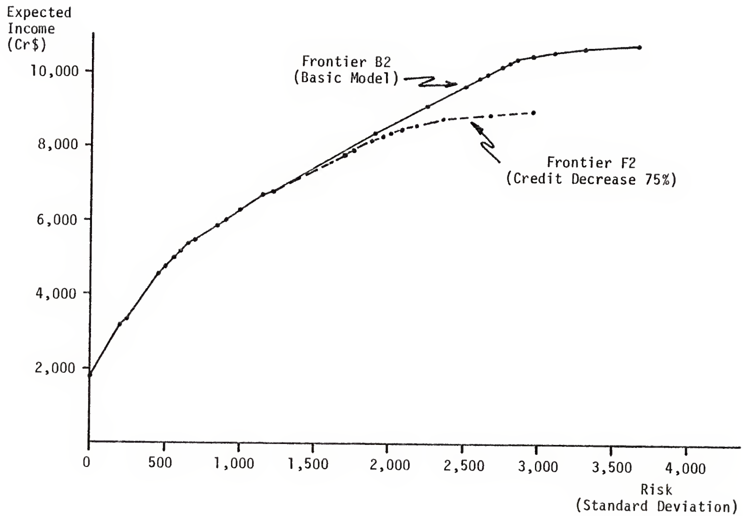

Figure 16. Medium farm efficiency frontier B2 and F2 (credit decrease of 75 percent) for minimum risk farm plans

Table 40. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier F2 (credit reduction of 75 percent on the medium farm), by expected income level

Item and unit	Quadratic programming solutions					LP solution
	1	2	3	4	5	6
Expected income (Cr$)	6,800	7,800	8,200	8,500	8,800	9,007
Standard deviation (Cr$)	1,210	1,663	1,874	2,070	2,375	2,961
Coefficient of variation	.177	.213	.228	.244	.270	.329
Cropping pattern						
Owner-operated area:						
Cotton (ha)	1.18	1.69	3.40	4.79	7.48	14.22
Rice (ha)	1.73	1.73	1.73	1.73	1.73	1.73
Cotton/beans/corn (ha)	0.68	1.08	1.51	2.09	2.64	---
Cotton/beans (ha)	0.12	0.30	0.28	---	---	---
Cattle (a-u)	8.13	11.94	12.36	12.64	12.43	12.97
Forage (ha)	0.49	0.72	0.74	0.76	0.75	0.78
Sharecropped area:						
Cassava (ha)	0.25	0.22	0.17	0.13	0.08	0.02
Cotton/beans/corn (ha)	17.15	14.88	11.53	8.87	5.72	1.58
No. of sharecroppers	1.74	1.51	1.17	0.90	0.58	0.16

Table 41. Resource requirements for selected farm plans on efficiency frontier F2 (credit reudction of 75 percent on the medium farm), by expected income level

Item and unit	Selected farm plans					LP solution
	1	2	3	4	5	6
Expected income (Cr$)	6,800	7,800	8,200	8,500	8,800	9,007
Land (ha)						
Class "A"	1.73	1.73	1.73	1.73	1.73	1.73
Class "B"	19.89	18.90	17.63	16.63	16.63	16.63
Pasture	28.53	89.40	39.44	39.33	38.84	40.33
Fallow	0	0	0	0	0	0
Sharecropping	17.42	15.11	11.70	8.99	5.76	1.64
Family labor (m/d)						
1	38.50	38.50	38.50	38.50	38.50	38.50
2	38.50	38.50	38.50	38.50	38.50	38.50
3	38.50	38.50	38.50	38.50	38.50	38.50
4	38.50	38.50	38.50	38.50	38.50	38.50
5	38.50	38.50	38.50	38.50	38.50	38.50
6	38.50	38.50	38.50	38.50	38.50	38.50
Total	231.00	231.00	231.00	231.00	231.00	231.00
Temporary labor (m/d)						
1	0	0	0	5.64	16.07	14.51
2	7.25	33.24	66.16	92.63	137.50	137.50
3	0	0	0	0	15.43	36.17
4	0	0	0	0	0	0
5	0	0	0	0	0.96	41.93
6	0	0	0	0	0	10.05
Total	7.25	33.24	66.16	98.27	169.96	240.16
Permanent labor (m/d)						
1	13.10	22.86	32.74	35.30	35.30	35.30
2	35.30	35.30	35.30	35.30	35.30	35.30
3	0	0	10.89	26.09	35.30	35.30
4	0	0	0	0	10.38	10.50
5	0	0	0	5.98	35.30	35.30
6	0	0	0	0	20.21	35.30
Total	48.40	58.16	145.09	200.94	171.79	187.00
Sharecropper labor (m/d)						
1	33.21	28.81	22.31	17.14	10.99	3.12
2	33.21	28.81	22.31	17.14	10.99	3.12
3	9.68	20.49	22.31	17.14	10.99	3.12
4	0	6.94	11.55	15.38	10.99	3.12
5	1.76	7.24	16.08	17.14	10.99	3.12
6	33.21	28.81	22.31	17.14	10.99	3.12
Total	111.07	121.10	116.87	101.08	65.94	18.72
Capital (Cr$)						
Operating	6,775	7,847	7,666	7,542	7,633	7,403
Investment	3,510	5,157	5,338	5,462	5,371	5,601
Credit limit	10,285	13,004	13,004	13,004	13,004	13,004

the activities of frontier F2 compared to frontier B2, for similar expected income levels, are a decrease in cattle, an increase in owner-operator cotton, and a decrease in sharecropper cotton/beans/corn. Also, the number of sharecroppers employed is reduced, pasture land is under-utilized, and no fallow land is brought into use.

In summary, a credit reduction of 75 percent would have important adverse effects on medium farmers.

Large Farm

Frontiers F3 and G3, in which credit available to the large farmer is reduced by 75 and 50 percent, respectively, and basic model frontier B3 are presented in Figure 17. The numerical results are given in Tables 42, 43, 44, and 45. For frontier F3, credit becomes an effective constraint at the Cr$13,200 level of expected income, while for frontier G3 it becomes effective at the Cr$18,200 level of expected income. The reduction in the amount of credit available to the large farmer has adverse effects on risk and income level.

While the small and medium farmers would not be affected by a 50 percent reduction in credit, this reduction would result in an increase in risk for the large farm at the upper income level. One of the major explanations for these results is that large farmers use more credit because they allocate a higher proportion of their land to sharecroppers.

The major impact of credit reductions on large farms is the reduction in income potential. Thus, the LP solutions for frontiers B3, F3, and G3 and the actual plan are summarized in Table 46 for convenience when comparing the results. The effects of the 50 percent reduction in credit are relatively minor with the exception of the

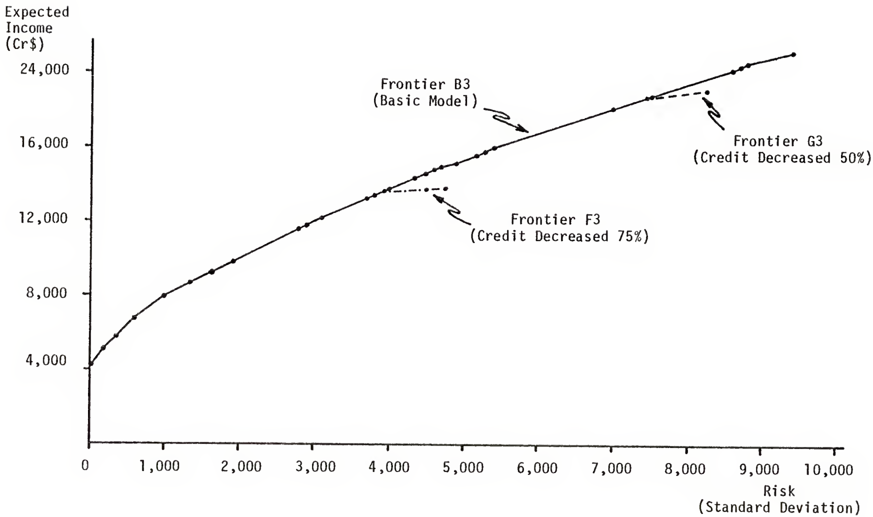

Figure 17. Large farm efficiency frontiers B3, F3, and G3 (credit decrease) for minimum risk farm plans

Table 42. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier F3 (credit reduction of 75 percent on the large farm), by expected income level

Item and unit	Quadratic programming solutions				LP solution
	1	2	3	4	5
Expected income (Cr$)	13,200	13,300	13,500	13,600	13,916
Standard deviation (Cr$)	3,658	3,738	3,856	3,947	4,751
Coefficient of variation	.277	.281	.286	.290	.341
Cropping pattern					
Owner-operated area:					
Cotton (ha)	4.86	5.83	6.96	8.50	18.32
Rice (ha)	1.07	1.07	1.07	1.07	1.07
Cotton/beans/corn (ha)	3.47	3.67	3.95	3.86	---
Cotton/beans (ha)	0.87	0.52	0.55	---	---
Cattle (a-u)	24.88	24.91	24.86	24.97	25.67
Forage (ha)	2.24	2.24	2.24	2.25	2.31
Sharecropped area:					
Cassava (ha)	0.46	0.45	0.43	0.41	0.33
Cotton/beans/corn (ha)	31.34	30.45	28.97	28.09	22.17
No. of sharecroppers	3.18	3.09	2.94	2.85	2.25

Table 43. Resource requirements for selected farm plans on efficiency frontier F3 (credit reduction of 75 percent on the large farm), by expected income level

Item and unit	Selected farm plans				LP solution
	1	2	3	4	5
Expected income (Cr$)	13,200	13,300	13,500	13,600	13,916
Land (ha)					
Class "A"	1.07	1.07	1.07	1.07	1.07
Class "B"	43.13	43.13	43.13	43.13	43.13
Pasture	87.84	87.92	87.74	88.16	90.60
Fallow	0	0	0	0	0
Sharecropping	31.76	40.87	29.42	28.53	22.49
Family labor (m/d)					
1	32.90	32.90	32.90	32.90	32.90
2	32.90	32.90	32.90	32.90	32.90
3	32.90	32.90	32.90	32.90	32.90
4	32.90	32.90	32.90	32.90	32.90
5	32.90	32.90	32.90	32.90	32.90
6	32.90	32.90	32.90	32.90	32.90
Total	197.40	197.40	197.40	197.40	197.40
Temporary labor (m/d)					
1	0	0	0	0	0
2	94.74	103.93	125.00	125.00	125.00
3	0	0	0	2.97	33.30
4	0	0	0	0	0
5	0	0	0	0	59.84
6	0	0	0	0	8.95
Total	94.74	103.93	125.00	127.97	227.09
Permanent labor (m/d)					
1	0	0	4.91	5.23	3.09
2	30.93	30.93	30.93	30.93	30.93
3	12.26	18.39	29.64	30.93	30.93
4	0	0	0	0	0
5	0	8.54	22.07	30.93	30.93
6	0	0	0	3.11	30.93
Total	43.19	57.86	87.55	101.13	126.81
Sharecropper labor (m/d)					
1	58.19	58.86	16.12	54.40	42.90
2	60.57	58.86	56.12	54.40	42.90
3	60.57	58.86	56.12	54.40	42.90
4	38.97	39.91	42.88	41.47	30.24
5	60.57	58.86	56.12	54.40	42.90
6	43.65	47.50	53.83	54.40	42.90
Total	322.52	322.85	321.19	313.47	244.74
Capital (Cr$)					
Operating I	15,600	15,600	15,600	15,600	15,600
Operating II	2,182	2,172	2,196	2,139	1,810
Investment	11,855	11,855	11,831	11,888	12,217
Credit limit	29,627	29,627	29,627	29,627	29,627

Table 44. Standard deviation, coefficient of variation, and minimum risk farm plans for frontier G3 (credit reduction of 50 percent on the large farm), by expected income level

Item and unit	Quadratic programming solutions			LP solution
	1	2	3	4
Expected income (Cr$)	18,200	18,800	18,900	19,149
Standard deviation (Cr$)	7,029	7,495	7,635	8,265
Coefficient of variation	.386	.399	.404	.432
Cropping pattern				
Owner-operated area:				
Cotton (ha)	2.51	3.10	6.53	15.79
Rice (ha)	1.07	1.07	1.07	1.07
Cotton/beans/corn (ha)	5.33	4.98	3.64	---
Cattle (a-u)	54.60	58.60	58.84	59.46
Forage (ha)	4.91	5.27	5.30	5.35
Sharecropped area:				
Cassava (ha)	0.44	0.43	0.40	0.32
Cotton/beans/corn (ha)	29.96	29.37	27.30	21.68
No. of sharecroppers	3.04	2.98	2.77	2.20

Table 45. Resource requirements for selected farm plans on efficiency frontier G3 (credit reduction of 50 percent on the large farm), by expected income level

Item and unit	Selected farm plans 1	2	3	LP solution 4
Expected income (Cr$)	18,200	18,800	18,900	19,149
Land (ha)				
Class "A"	1.07	1.07	1.07	1.07
Class "B"	43.13	43.13	43.13	43.13
Pasture	192.73	206.84	207.71	209.99
Fallow	0	0	0	0
Sharecropping	30.38	29.78	27.67	21.98
Family labor (m/d)				
1	32.90	32.90	32.90	32.90
2	32.90	32.90	32.90	32.90
3	32.90	32.90	32.90	32.90
4	32.90	32.90	32.90	32.90
5	32.90	32.90	32.90	32.90
6	32.90	32.90	32.90	32.90
Total	197.40	197.40	197.40	197.40
Temporary labor (m/d)				
1	0	3.08	2.34	0.29
2	125.00	125.00	125.00	125.00
3	12.19	17.67	28.24	56.81
4	0	0	0	0
5	0	0	28.85	77.25
6	0	0	0	34.64
Total	137.19	145.75	176.43	293.99
Permanent labor (m/d)				
1	30.93	30.93	30.93	30.93
2	30.93	30.93	30.93	30.93
3	30.93	30.93	30.93	30.93
4	16.96	20.93	21.03	21.26
5	23.50	30.93	30.93	30.93
6	11.80	18.12	30.93	30.93
Total	145.05	162.77	175.68	175.91
Sharecropper labor (m/d)				
1	57.93	56.78	52.77	41.92
2	57.93	56.78	52.77	41.92
3	57.93	56.78	52.77	41.92
4	57.93	56.78	52.77	41.92
5	57.93	56.78	52.77	41.92
6	57.93	56.78	52.77	41.92
Total	347.58	340.68	316.62	251.52
Capital (Cr$)				
Operating I	15,600	15,600	15,600	15,600
Operating II	14,222	15,763	15,646	15,349
Investment I	15,600	15,600	15,600	15,600
Investment II	10,389	12,291	12,408	12,705
Credit limit	55,811	59,254	59,254	59,254

Table 46. Actual plan and LP solutions for the basic model and with reduced credit, large farm

Item and unit	LP solutions			Actual plan
	Basic model, B3	75% credit reduction, F3	50% credit reduction, G3	
Expected income (Cr$)	20,685	13,916	19,149	20,392
Standard deviation (Cr$)	9,412	4,751	8,265	---
Coefficient of variation	.445	.341	.432	---
Cropping pattern				
Owner-operated area:				
Cotton (ha)	15.02	18.32	15.79	0.34
Rice (ha)	1.07	1.07	1.07	1.04
Cotton/beans/corn (ha)	---	---	---	5.12
Cattle (a-u)	69.85	25.67	59.46	70.00
Forage (ha)	6.29	2.31	5.35	5.46
Sharecropped area:				
Cassava (ha)	0.32	0.33	0.32	0.47
Cotton/beans/corn (ha)	21.48	22.17	21.68	31.93
Labor employed				
Family (m/d)	197.40	197.40	197.40	197.40
Temporary (m/d)	323.84	227.09	293.99	880.00
Permanent (m/d)	185.58	125.81	175.91	185.58
Sharecropper (m/d)	249.78	244.74	251.52	348.12
No. of sharecroppers	2.18	2.24	2.20	3.24

reduction in cattle. However, the 75 percent reduction in credit would result in a major reduction in income potential.

In conclusion, a reduction in credit available to farmers would have adverse effects on levels of risk and income on all farm sizes. However, because large farms have higher operating costs of their own and finance a larger number of sharecroppers, they are more vulnerable to credit reductions. A reduction in credit for medium and large landowners causes a shift towards more owner-operated cotton enterprises and away from cattle activities.

Summary of Effects of Changes on Expected Income Under the Assumption that the Choices of Coefficients of Variation Would Not Change

A comparison of the survey data with the basic model results shows that the farm plan corresponding to the Cr$10,176 level of expected income and coefficient of variation of .272 is most similar to the actual farm plan for the medium farm (see Table 13). If sharecroppers are replaced by other forms of labor and if the farmer is assumed to maintain the same attitude towards risk, i.e., if he prefers a farm plan with the same coefficient of variation as in the basic model, he would choose a farm plan with 33 percent less expected income when sharecroppers are excluded. In other words, the medium farmer would have his expected income decreased to Cr$6,800 in order to remain at a similar risk level. When the same assumptions are applied to the large farm, expected income would decrease from Cr$20,474 to approximately Cr$11,500, with an equivalent coefficient of variation of .426. This would mean a reduction of 44 percent in the expected income of the large farmer if he should choose to remain at the equivalent risk level when sharecroppers are excluded as an alternative source of labor.

When cotton enterprises are removed from the farm plans and farmers choose to remain at similar risk levels as those of the basic models, expected income levels would decrease from Cr$5,482 to Cr$5,300, from Cr$10,176 to Cr$5,500, and from Cr$20,474 to Cr$8,900, for small, medium, and large farms, respectively. These changes would amount to a 3 percent, 46 percent, and 57 percent decrease, respectively, in expected income for each farm size. Thus, as farm size increases, the greater is the reduction in expected income when cotton enterprises are removed from the farm plans and farmers choose to remain at similar levels of risk as in the basic models.

However, when cotton price is increased by 15 percent and farmers choose to remain at similar risk levels as those of the basic models, that is, with a coefficient of variation of .176, .272, and .426 for small, medium, and large farms, respectively (see Tables 11, 13, and 15), expected income levels would increase. Expected income would increase from Cr$5,482 to Cr$5,700 for small farms, from Cr$10,176 to a little under Cr$11,052 for medium farms, and from Cr$20,474 to Cr$22,177 for large farms, which means a 4 percent, 9 percent and 8 percent increase, respectively.

Finally, if credit is reduced by 75 percent and farmers are assumed to maintain the same attitude towards risk, that is, if they are consistent in choosing farm plans with similar coefficients of variation as those given in the basic model when compared to the actual farm plans, expected income would be the same for small and medium farms. However, for large farms the same level of risk would not be achieved since the maximum feasible solution (LP solution) of Cr$13,916 expected income would be obtained at a coefficient of variation of .341 which is less

then .426 achieved in the basic model. A 75 percent decrease in credit available to large farms would force farmers to choose farm plans at lower risk levels than they would in the basic model.

CHAPTER VI
SUMMARY, CONCLUSIONS, IMPLICATIONS, AND LIMITATIONS

Summary and Conclusions

Economic development has been the major concern of the Brazilian government for several decades. However, the majority of policies and government programs designed to promote development have resulted in an unbalanced pattern of growth among regions, sectors, and socio-economic groups. Disparities in growth are more palpable in Northeast Brazil where agriculture is the most neglected sector and where the incidence of poverty is especially high among landless rural workers. One of the major reasons for the unsatisfactory performance of agriculture in the Northeast is that economic information with respect to the relationships among socio-economic groups is still very deficient.

The purpose of this research is to improve the understanding of the economic relationship between the landowner and the sharecropper in the economy of the Semi-Arid Region of the Northeast. The specific objectives were, for samll farms and for two sizes of sharecropper farms, to (a) determine the risk associated with different enterprise combinations; (b) develop efficient sets of farm plans which minimize income variance for given levels of expected income; and (c) determine the effects of changes in sharecropping conditions, dropping cotton from production, changes in cotton prices, and reductions in credit availability on employment, enterprise combinations, output, incomes, and risk.

The municipios (counties) of Caicó and Florânia in the State of Rio Grande do Norte were selected as the study area because of their representative characteristics of the semi-arid region. Most of the primary data used were taken from a random sample of farms conducted in 1973/1974 by the SUDENE/World Bank project.

Linear and quadratic programming models were used to estimate minimum risk (income variance) for given levels of income. The programming models account for major relationships between sharecroppers and landowners such as production activities on owner-operated and sharecropped parts of the farm, sharecroppers' share of production, market margin on sharecroppers' production, sharecropper labor (sujeicão labor), and sharecropper consumption. A sharecropper sub-model was developed and its optimized results were introduced as activities in the representative medium and large farm models. The basic assumption underlying the models was that the sharecropper has some decision-making power within the framework of the sharecropping contract.

Activities involving cotton were less risky than other crop activities. Income from cattle also had a relatively low variance. The level of risk increased at an increasing rate as the level of income increased. Small farmers appeared to have a higher risk-aversion than medium farmers, and the latter have a higher risk-aversion than large farmers, i.e., as farm size increased, riskier farm plans were chosen by farmers. Thus, actual farm plans produced expected incomes below the maximum levels but their variances were less than variances associated with maximum expected incomes. However, sharecroppers were not risk adverse but the decisions may have been a result of highly constrained

decisions.[1] Land was a restrictive factor only for sharecroppers and small farmers. Labor was a limiting factor for medium and large farmers. For small farmers, labor was restrictive only in critical months. Financial resources, with the exception of sharecroppers, were not a limiting factor.

Results from the sensitivity analysis show that, when sharecroppers were excluded as a source of labor, higher risks in relation to expected income were incurred by medium and large farmers. Thus, a major reason why landowners prefer to employ sharecroppers is this reduction in risk at given levels of income. When cotton was dropped from the farm plans, land was shifted to pasture and cattle, and less income was generated at given levels of risk. When cotton price was increased 15 percent, more land was allocated to sharecroppers and risk was reduced in relation to income levels. A reduction in credit by 50 percent would have no effect on small and medium farmers and only minor effects on large farmers. A reduction of 75 percent in credit affected all farmers. The major effect was on large farms. There was a substantial reduction in the cattle activity and in potential income levels.

The opportunities to reduce risk and/or increase expected income levels by merely reallocating existing resources appears to be very limited. Thus, for the future, agronomic research should be emphasized and the introduction of alternative enterprises and new technologies should be investigated. Without serious efforts to develop new

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[1]This result seems to be consistent with findings of a recent study by means of mind experiments that involved choices between risky and sure farm alternatives which was used to assess risk attitudes of samples of small farm owners and sharecroppers in Brazil. One of the conclusions of the study, done with data from Canindé, State of Ceará, is that risk aversion tends to be more common and perhaps greater among small owners than among sharecroppers [Dillon and Scandizzo, 1978].

alternatives, the opportunities for increasing income and welfare in the region are quite limited.

Also, in order to develop more reliable estimates of the effects of credit policy, information on farmers' own financial resources and land values are needed.

A better understanding of interrelationships among the several socio-economic groups in the production process is needed in the making of government policies and programs directed to ameliorate inequities in income distribution. A more concerted effort needs to be made to study household and production relationships. It is believed that only a better perception of these relations could result in improvements in labor allocation by low-income groups.

Additional Implications

An important implication of the results of the sensitivity analysis, when sharecroppers were removed from the farm plans, was found. Given the traditional technology in the study area, it would be very difficult for medium and large farmers to achieve more intensive levels of land use in the absence of sharecroppers. This implication is a result of the inelastic nature of labor supply, especially in periods of peak labor demand. To insure themselves against labor shortages and income variability, medium and large farmers rely on sharecroppers. The sharecropping system prevailing in this area, regulated by the sharecropping contract, is a rational way in which landowners can guarantee labor supplies all year around and especially in critical periods at lower costs. Thus, sharecroppers provide labor for the sharecropped part of the farm, labor for the owner-operated portion of the farm (<u>sujeicão</u>

labor), and eventually supply part of the temporary wage labor of other neighboring farms. In this fashion, the sharecropping system is consistent with recent theories of structural subordination of "small" production.[2] On the other hand, sharecroppers are better off than if they were exclusively rural wage workers. According to the survey data, sharecroppers would earn, on a man/day basis, an average daily income of Cr$6.54 compared to a Cr$7.00 daily wage paid to temporary hired labor. However, additional benefits such as staple food, housing, health, and well-being provided by the landlord offset the balance between sharecroppers and wage workers. Besides, because of seasonality in the demand for labor, rural workers on a temporary basis may not find work year round. In addition, sharecroppers praise highly the sharecropper-landlord relationship in which the rights and duties of each party are clearly delineated. On the other hand, a landlord who seriously neglects his duties could lose his workers and would find replacements scarce [Johnson, 1971].

Another implication of this study, especially related to the results from the simulation when cotton land was converted into pasture by deleting cotton from the farm plans, is that there are very few agricultural products in which the region has a comparative advantage. Since cotton is the most important source of income and employment in the region, any attempt to abandon this crop would result in serious socio-economic problems which would affect the entire

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[2]These theories, starting from the concept of a duality in the Arthur Lewis sense, attempt to explain the interrelationships between two basic segmentations observed in agriculture, "small" and "capitalistic" production. The former is basically characterized by the utilization of family labor and, therefore, has its production range limited in size, while the latter is basically characterized by the use of wage labor; thus, no "natural" limitation on size or scale of production is imposed [Rezende, 1978].

local economy. In consequence, government effort should be oriented to improving cotton productivity. Agronomic research is highly recommended since cotton productivity has hardly changed in decades. In addition, agronomic and economic research should be stimulated in order to develop alternative crops for which the requirements and profitability could compete with cotton.[3] The survey data indicated no effective cotton grading system in the area. Government regulation of the cotton marketing system by enforcing a grading system would improve cotton production. Differential prices would stimulate farmers to cultivate long-fiber moco cotton which yields more income at given levels of risk.

Limitations

A great deal of information that may be useful to policy makers is generated by studies using programming techniques. However, as in any other methodology, mathematical programming has limitations which must be recognized. Among these limitations, well treated in the literature,[4] special attention must be given to the data and modeling process. The data used to measure the technical coefficients and resource restrictions were drawn from a survey conducted by the SUDENE/World Bank project. However, given the nature of the objectives of this study, several improvements were needed. As an example, labor requirements for each activity were only available by farm task. Therefore, in order

[3] During the author's field trip to the study area, a visit was made to the experiment station of Cruzeta. There he became aware of recent experiments with sorghum. According to local agronomists, sorghum has 95 percent of the nutrient value of corn and produced good yields in several experiments around the study area.

[4] The assumptions, limitations, and the relations of programming with the theory of the firm are thoroughly discussed in the literature [Gauss, 1975; Baumol, 1972; Hadley, 1963; Heady and Candler, 1958].

to include seasonality aspects of labor, the related technical coefficients had to be transformed. This was done by associating labor requirements by farm task with the month that these services were performed. Another example is the adjustments made in the coefficients of cattle enterprises so that differences among farm sizes could be accounted for. Because of no information on "household activities", alternative sources of income for sharecroppers and small farmers were neglected. An additional limitation was the time series data used in the variance-covariance matrix of enterprise returns. These data may contain aggregation bias. This bias is a result of the fact that the aggregation process is obtained by state averages which may not account for variability across farms.

Programming models in nature are simplified abstractions of complicated processes. Thus, several simplifications were imposed. Long-term investments in the production process were largely ignored. Because a single-period process was assumed, investments in building, equipment, and other structures were omitted. The livestock investments decisions were treated in a simplified way, as were decisions with respect to cotton investments.

Even though limitations may impose restrictions on the results, they were necessary to keep the problem manageable and because, in many cases, no alternative data were available.

GLOSSARY

Acude. Reservior of water built by the government as prevention against droughts.

Baxio. Moist, low-lying land.

BNB. Abbreviation for Banco do Nordeste do Brasil S.A., Northeast of Brazil Bank.

Bóia-fria. Nomad rural workers. Literally means cold meal. Most of these workers live in the cities and bring their lunch with them as opposed to those who live near their work and have a hot meal.

CEPA-RN. Abbreviation for Comissão Estadual de Planejamento Agrícola do Rio Grande do Norte, State Commission for Agricultural Planning of Rio Grande do Norte.

Cruzeiro. Brazilian monetary unit, exchanging in 1973 at Cr$6.13 to the U.S. dollar.

EMBRAPA. Abbreviation for Empresa Brasileira de Pesquisa Agropecuária, Brazilian Agricultural Research Company, associated with the Ministry of Agriculture

Estacas. Stakes used for supporting a plant.

Fazenda. Large landholding.

FIBGE. Abbreviation for Fundacão Instituto Brasileiro de Geografia e Estatistica, Brazilian Institute of Geography and Statistics Foundation.

Fortaleza. Seaport in Northeast Brazil, capital of Ceará state.

Hectare. 2.47 acres.

Herbáceo. Low-growing annual cotton variety with higher yields when rainfall is more abundant. However, it is not very drought resistant and grows best in low-lying humid soil, especially under irrigation.

IPEA. Abbreviation for Instituto de Planejamento Econômico e Social, Economic and Social Planning Institute, under the Secretary of Planning.

Mocó. Perennial long-staple tree cotton, highly drought resistant, with economic life of about five years and usually planted in hill plots.

Municipio. Smallest level of Brazilian government. Equivalent to the U.S. county.

Natal. Seaport in Northeast Brazil, capital of Rio Grande do Norte state.

Palma. _Opuntia sp._, a catus, native of the semi-arid Northeast Brazil, used for forage.

Recife. Seaport in Northeast Brazil, capital of Pernambuco state.

Salvador. Seaport in Northeast Brazil, capital of Bahia state.

Sertão. Semi-arid backlands of Northeast Brazil.

Sertão do Seridó. Part of the Sertão which includes the valley of the Seridó River.

SUDENE. Abbreviation for Superintendência de Desenvolvimento do Nordeste, Superintendency for the Development of the Northeast, under the Ministry of the Interior.

Sujeicão. Consists of the obligation of the sharecropper to provide labor to the landowner for a daily wage that is less than that earned by other forms of labor. Literally means subjection.

SUPLAN. Abbreviation for Subsecretaria de Planejamento e Orcamento, Subsecretary of Planning and Budget, under the Ministry of Agriculture.

UFPe. Abbreviation for Universidade Federal de Pernambuco, Federal University of Pernambuco.

Vazante. Land on the margin of a reservoir.

Verdão. Cotton cross between _mocó_ and _herbáceo_, has an economic life of approximately two to three years.

APPENDICES

APPENDIX A
GENERAL STATISTICAL INFORMATION

Table A-1. Distribution of farms by size, Rio Grande do Norte, sample area (Caicó and Florânia), 1970

Size in hectares	Number	Percent	Area (ha)	Percent
Rio Grande do Norte	103,630	100.00	4,571,683	100.00
under 10	63,964	61.72	185,966	4.07
10-99	31,785	30.67	1,022,061	22.36
100-999	7,179	6.93	1,872,957	40.97
1,000-9,999	591	0.57	1,275,519	27.90
over 10,000	13	0.01	215,180	4.70
unclassified	98	0.10	---	---
Sample area	3,317	100.00	171,401	100.00
under 10	2,036	61.38	3,844	2.24
10-99	877	26.44	32,354	18.88
100-999	387	11.67	101,747	59.36
1,000-9,999	17	0.51	33,456	19.52
over 10,000	---	---	---	---
unclassified	---	---	---	---

SOURCE: Calculated from census data, 1970.

Table A-2. Cotton production and area by state, Northeast, Brazil, 1971

State	Production		Area	
	Tons	Percent	1,000 ha	Percent
Maranhão	26,136	2.84	107	3.42
Piauí	27,915	3.03	104	3.32
Ceará	379,397	41.24	1,250	39.96
Rio Grande do Norte	110,513	12.01	500	15.99
Paraíba	153,227	16.65	513	16.40
Pernambuco	106,343	11.56	391	12.50
Alagoas	21,066	2.29	76	2.43
Sergipe	7,726	0.84	29	0.93
Bahia	87,759	9.54	158	5.05
Northeast	920,082	100.00	3,128	100.00

SOURCE: Banco do Nordeste do Brasil S.A. [1973].

Table A-3. Production of major crops for the state of Rio Grande do Norte, Brazil, 1960/1970[a]

Products	Units	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Cotton	tons	124,782	121,418	118,054	114,691	111,327	107,963	104,599	101,235	97,871	94,508	91,144
Beans	tons	49,225	50,053	50,881	51,709	52,537	53,365	54,193	55,021	55,850	56,678	57,506
Corn	tons	63,394	62,555	62,717	62,879	63,041	63,203	63,365	63,527	63,689	63,851	64,013
Cassava	tons	169,478	198,981	228,485	257,988	287,491	316,995	346,408	376,001	405,504	435,008	464,511
Sisal	tons	8,760	17,686	26,613	35,539	44,465	53,391	62,318	71,244	80,170	89,096	98,023
Sweet potato	tons	114,254	119,476	124,697	129,918	135,139	140,360	145,582	150,803	156,024	161,245	116,467
Sugarcane	tons	323,044	355,374	387,703	420,033	452,362	484,692	517,021	549,351	581,680	614,010	646,339
Fava	tons	11,870	12,216	12,563	12,909	13,256	13,602	13,949	14,295	14,642	14,988	15,335
Banana[b]	1,000 stocks	1,632	2,412	3,192	3,972	4,751	5,531	6,311	7,091	7,871	8,651	9,431

[a]Adjusted data.

[b]Stock = 10 dozen.

SOURCE: SUDENE [1972, p. 28].

Table A-4. Area of major crops for the state of Rio Grande do Norte, Brazil, 1960/1970[a]

Products	Hectares										
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Cotton	403,374	415,402	427,430	439,459	451,487	463,515	475,543	487,571	499,599	511,628	523,656
Beans	114,810	117,772	120,734	123,697	126,659	129,621	132,583	135,546	138,508	141,470	144,433
Corn	110,240	111,647	113,053	114,460	115,866	117,273	118,680	120,086	121,493	112,899	124,306
Cassava	33,363	37,364	41,366	45,367	49,368	53,370	57,371	61,372	65,374	69,375	73,376
Sisal	9,472	18,458	27,445	36,431	45,418	54,405	63,391	72,378	81,364	90,351	99,337
Sweet potato	14,692	15,303	15,915	16,526	17,137	17,749	18,360	18,972	19,583	20,194	20,806
Sugarcane	6,632	7,292	7,952	8,612	9,272	9,932	10,592	11,253	11,913	12,573	13,233
Fava	33,923	34,364	34,805	35,246	35,687	36,128	36,569	37,010	37,451	37,892	38,333
Banana	1,818	2,103	2,388	2,673	2,958	3,243	3,527	3,812	4,097	4,382	4,667

[a]Adjusted data.

SOURCE: SUDENE [1972, p. 26].

Table A-5. Average yield per hectare of major crops for the state of Rio Grande do Norte, Brazil, 1960/1970[a]

Products	Unit	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Cotton	kg/ha	305	291	278	264	250	236	222	208	194	181	167
Beans	kg/ha	437	431	424	418	411	405	398	392	385	379	372
Corn	kg/ha	581	560	557	546	534	522	511	499	487	476	464
Cassava	kg/ha	5,311	5,416	5,521	5,626	5,731	5,836	5,942	6,047	6,152	6,257	6,362
Sisal	kg/ha	1,022	1,017	1,011	1,006	1,001	996	991	986	981	976	971
Sweet potato	kg/ha	7,761	7,783	7,805	7,826	7,848	7,870	7,892	7,914	7,936	7,958	7,980
Sugarcane	kg/ha	48,227	48,350	48,423	48,496	48,569	48,641	48,714	48,787	48,860	48,933	49,006
Fava	kg/ha	360	363	365	368	371	373	370	379	382	384	387
Banana[b]	1,000 stocks/ha	2,197	2,114	2,032	1,949	1,867	1,784	1,702	1,619	1,537	1,454	1,372

[a]Adjusted data.

[b]Stock = 10 dozen

SOURCE: SUDENE [1972, p. 31].

Table A-6. Value of agricultural production of major crops for the state of Rio Grande do Norte, Brazil, 1960/1970

Products	Value (Cr$1,000.00)										
	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Cotton	3,776	4,776	7,617	11,866	25,830	39,400	32,242	54,778	55,712	56,169	65,625
Beans	764	1,049	3,322	3,896	4,635	11,742	16,753	16,626	20,947	25,953	19,987
Corn	383	581	1,287	2,023	2,825	5,670	6,455	12,925	13,224	12,509	6,247
Cassava	342	568	1,424	1,687	2,903	5,378	12,885	28,086	25,331	16,638	18,505
Sisal	320	499	1,303	2,364	4,811	5,292	11,239	18,883	24,358	24,439	26,224
Sweet potato	336	548	1,038	1,607	2,018	3,927	10,443	12,736	10,910	13,109	13,730
Sugarcane	203	323	579	1,110	2,014	3,902	4,534	8,166	11,278	16,356	17,082
Fava	233	306	938	1,214	1,443	3,596	5,664	5,591	7,308	6,940	4,945
Banana	262	445	799	1,273	2,915	4,637	6,318	12,189	12,571	16,128	17,657

SOURCE: SUDENE [1972, p. 33].

APPENDIX B
RESOURCE ENDOWMENT AND ENTERPRISE BUDGETS

Table B-1 Resource endowment for the farms of the study area, 1973

Item	Unit	Sharecropper Typical plot	Farm size (ha)		
			< 50	50-199	≥ 200
Average farm size	ha	10.00	18.81	119.27	441.77
Land:					
Cropland "A"	ha	---	0.86	1.73	1.07
Cropland "B"	ha	10.00	2.75	5.92	10.70
Pasture land	ha	---	7.43	67.51	246.56
Fallow land	ha	---	3.22	19.09	101.41
Other land	ha	---	4.55	14.31	49.60
Sharecropper land	ha	---	---	10.71	32.43
Labor:					
Family	m/d[a]	545.60	217.00	231.00	197.40
Permanent	m/d	---	37.50	211.80	185.58
Temporary	m/d	90.00	262.50	55.88	880.00
Sujeicão	m/d	114.40	---	---	---
Sharecropper	m/d	---	---	---	---
Capital and financial resources:					
Equipment	Cr$	---	82.23	1,509.55	4,181.33
Structures	Cr$	---	10,369.10	25,131.74	78,628.94
Cattle herd	Cr$	---	14,093.88	27,890.38	94,837.80
Operating capital	Cr$	810.80	2,836.14	7,355.04	21,184.92
Credit limit[b]	Cr$	---	17,795.79	52,017.50	118,508.61

[a]m/d is man per day.

[b]80 percent of land value.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976].

Table B-2. Prices for several activities, study area, 1973

Activity	Cruzeiros (Cr$)
Permanent labor	6.00 / m/d[a]
Temporary labor	7.00 / m/d
Sujeicão labor	4.00 / m/d
Borrowing money for operating and investment expenses under Cr$15,600.00	.10/1.00
Borrowing money for operating and investment expenses above Cr$15,600.00	.15/1.00

[a]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Banco do Brasil S.A.

Table B-3. Gross returns, costs, and resource requirements for the production of one hectare of cotton in land type "B", 1973

Item	Unit		Amount
(1) Gross returns[a]	kg/ha		201.26
	Cr$		402.52
(2) Operating costs[a]			
Seeds	Cr$	0.24	
Insecticides and pesticides	Cr$	0.09	
Total	Cr$		0.33
(3) Labor[a]			
Jan/Feb	m/d[b]	0.58	
Mar/Apr	m/d	9.08	
May/June	m/d	5.20	
July/Aug	m/d	1.09	
Sep/Oct	m/d	7.61	
Nov/Dec	m/d	4.34	
Total			27.90
(4) Gross margin	Cr$		402.19
Expected gross margin	Cr$		351.32

[a]Represents averages for the 5-year cycle.

[b]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-4. Gross returns, costs, and resource requirements for the production of one hectare of rice in land type "A", 1973

Item	Unit		Amount
(1) Gross returns	kg/ha		1,206.84
	Cr$		1,810.26
(2) Operating costs			
Fertilizer	Cr$	1.63	
Seeds	Cr$	0.58	
Insecticides and pesticides	Cr$	0.03	
Total	Cr$		2.24
(3) Labor			
Jan/Feb	m/d[a]	43.47	
Mar/Apr	m/d	45.43	
May/June	m/d	16.47	
July/Aug	m/d	15.00	
Sep/Oct	m/d	---	
Nov/Dec	m/d	8.44	
Total	m/d		128.81
(4) Gross margin	Cr$		1,808.02
Expected gross margin	Cr$		674.18

[a]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-5. Gross returns, costs, and resource requirements for the production of one hectare of beans in land type "A", 1973

Item	Unit	Amount	
(1) Gross returns	kg/ha		346.02
	Cr$		692.04
(2) Operating costs			
Fertilizer	Cr$	6.67	
Seeds	Cr$	7.09	
Estacas (cuttings)	Cr$	2.89	
Insecticides and pesticides	Cr$	6.13	
Total	Cr$		22.78
(3) Labor			
Jan/Feb	m/d[a]	5.58	
Mar/Apr	m/d	2.23	
May/June	m/d	4.64	
July/Aug	m/d	29.49	
Sep/Oct	m/d	6.32	
Nov/Dec	m/d	4.46	
Total	m/d		52.72
(4) Gross margin	Cr$		669.26
Expected gross margin	Cr$		874.04

[a]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-6. Gross returns, costs, and resource requirements for the production of one hectare of corn in land type "B", 1973

Item	Unit		Amount
(1) Gross returns	kg/ha		427.17
	Cr$		213.59
(2) Operating costs			
Insecticides and pesticides	Cr$	0.89	
Total			0.89
(3) Labor			
Jan/Feb	m/d[a]	6.96	
Mar/Apr	m/d	27.93	
May/June	m/d	9.78	
July/Aug	m/d	5.60	
Sep/Oct	m/d	2.24	
Nov/Dec	m/d	2.24	
Total	m/d		54.75
(4) Gross margin	Cr$		212.70
Expected gross margin	Cr$		280.93

[a]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-7. Gross returns, costs, and resource requirements for the production of one hectare of cassava in land type "B", 1973

Item	Unit		Amount
(1) Gross returns	kg/ha		3,985.94
	Cr$		398.59
(2) Operating costs			
Estacas (cuttings)	Cr$	126.07	
Insecticides and pesticides	Cr$	0.92	
Total	Cr$		126.99
(3) Labor			
Jan/Feb	m/d[a]	10.37	
Mar/Apr	m/d	21.10	
May/June	m/d	19.77	
July/Aug	m/d	3.94	
Sep/Oct	m/d	3.95	
Nov/Dec	m/d	5.75	
Total	m/d		64.88
(4) Gross margin	Cr$		271.60
Expected gross margin	Cr$		648.42

[a]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-8. Gross returns, costs, and resource requirements for the production of one hectare of sweet potato in land type "A", 1973

Item	Unit		Amount
(1) Gross returns	kg/ha		4,567.61
	Cr$		1,370.28
(2) Operating costs			
Estacas (cuttings)	Cr$	277.50	
Insecticides and pesticides	Cr$	0.78	
Total	Cr$		278.28
(3) Labor			
Jan/Feb	m/d[a]	9.76	
Mar/Apr	m/d	2.79	
May/June	m/d	8.72	
July/Aug	m/d	34.30	
Sep/Oct	m/d	12.22	
Nov/Dec	m/d	5.57	
Total	m/d		73.36
(4) Gross margin	Cr$		1,092.00
Expected gross margin	Cr$		---

[a]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976].

Table B-9. Gross returns, costs, and resource requirements for the production of one hectare of cotton/beans/corn in land type "B", 1973

Item	Unit		Amount
(1) Gross returns[a]			
Cotton	kg/ha	156.83	
	Cr$	313.66	
Beans	kg/ha	124.85	
	Cr$	249.70	
Corn	kg/ha	280.01	
	Cr$	140.00	
Total	Cr$		703.36
(2) Operating costs[a]			
Seeds	Cr$	1.94	
Estacas (cuttings)	Cr$	0.53	
Insecticides and pesticides	Cr$	0.28	
Total	Cr$		2.75
(3) Labor[a]			
Jan/Feb	m/d[a]	5.17	
Mar/Apr	m/d	26.24	
May/June	m/d	8.56	
July/Aug	m/d	5.88	
Sep/Oct	m/d	7.05	
Nov/Dec	m/d	4.70	
Total	m/d		57.60
(4) Gross margin	Cr$		700.61
Expected gross margin	Cr$		1,047.46

[a]Represents average for a 5-year cycle.

[b]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-10. Gross returns, costs, and resource requirements for the production of one hectare of beans/corn in land type "A", 1973

Item	Unit	Amount	
(1) Gross returns			
Beans	kg/ha	195.66	
	Cr$	391.32	
Corn	kg/ha	385.71	
	Cr$	192.86	
Total	Cr$		584.18
(2) Operating costs			
Fertilizer	Cr$	4.82	
Seeds	Cr$	0.88	
Insecticides and pesticides	Cr$	0.47	
Total	Cr$		6.17
(3) Labor			
Jan/Feb	m/d[a]	7.75	
Mar/Apr	m/d	3.10	
May/June	m/d	5.24	
July/Aug	m/d	36.96	
Sep/Oct	m/d	8.63	
Nov/Dec	m/d	6.20	
Total	m/d		67.88
(4) Gross margin	Cr$		578.01
Expected gross margin	Cr$		654.40

[a]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-11. Gross returns, costs, and resource requirements for the production of one hectare of cotton/beans in land type "B", 1973

Item	Unit	Amount	
(1) Gross returns[a]			
Cotton	kg/ha	157.00	
	Cr$	314.00	
Beans	kg/ha	129.25	
	Cr$	258.50	
Total	Cr$		572.50
(2) Operating costs[a]			
Seeds	Cr$	3.18	
Insecticides and pesticides	Cr$	0.14	
Total	Cr$		3.32
(3) Labor[a]			
Jan/Feb	m/d[b]	3.43	
Mar/Apr	m/d	23.98	
May/June	m/d	8.59	
July/Aug	m/d	4.80	
Sep/Oct	m/d	7.20	
Nov/Dec	m/d	4.80	
Total	m/d		52.80
(4) Gross margin	Cr$		569.18
Expected gross margin	Cr$		867.63

[a]Represents average for a 5-year cycle.

[b]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-12. Average herd composition in animal-units by farm size, study area, 1973

Item	Equivalent animal-units	Farm size (ha)		
		< 50	50-199	≥ 200
Bulls	1.25	0.69	0.89	2.25
Wet brood cows	1.00	2.78	6.42	16.00
Dry brood cows	1.00	1.72	4.22	12.10
Yearling heifers/steers	0.75	2.21	4.18	25.95
Weaned calves	0.50	1.78	4.39	9.75
Unweaned calves	0.25	0.75	1.58	3.95
Total	---	9.93	21.68	70.00

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976].

Table B-13. Gross returns, costs, and resource requirements of one animal-unit of cattle enterprise for small farms, 1973

Item	Unit	Amount	
(1) Gross returns			
Beef	kg/a-u	52.00	
	Cr$	311.48	
Milk	l/a-u	151.00	
	Cr$	122.31	
Total	Cr$		433.79
(2) Total operating costs[a]	Cr$		121.70
(3) Annual investment costs[b]	Cr$		176.00
(4) Labor			
Jan/Feb	m/d[c]	0.25	
Mar/Arp	m/d	0.25	
May/June	m/d	0.38	
July/Aug	m/d	0.38	
Sep/Oct	m/d	0.38	
Nov/Dec	m/d	0.38	
Total	m/d		2.02
(5) Land			
Pasture	ha	0.75	
Total	ha		0.75
(6) Gross margin	Cr$		312.09
Expected gross margin	Cr$		260.37

[a]Includes expenses with salt, vaccines, etc.

[b]Includes expenses with fences, buckets, etc.

[c]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-14. Gross returns, costs, and resource requirements of one animal-unit of cattle enterprise for medium farms, 1973

Item	Unit	Amount	
(1) Gross returns			
Beef	kg/a-u	80.00	
	Cr$	479.20	
Milk	l/a-u	201.70	
	Cr$	163.38	
Total	Cr$		642.58
(2) Total operating costs[a]	Cr$		321.08
(3) Annual investment costs[b]	Cr$		432.00
(4) Labor			
Jan/Feb	m/d[c]	0.26	
Mar/Apr	m/d	0.26	
May/June	m/d	0.40	
July/Aug	m/d	0.40	
Sep/Oct	m/d	0.40	
Nov/Dec	m/d	0.40	
Total	m/d		2.12
(5) Land			
Pasture	ha	3.11	
Elephantgrass	ha	0.05	
Palma	ha	0.01	
Total	ha		3.17
(6) Gross margin	Cr$		321.50
Expected gross margin	Cr$		241.02

[a]Includes expenses with salt, vaccines, etc.

[b]Includes expenses with fences, buckets, etc.

[c]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-15. Gross returns, costs, and resource requirements of one animal-unit of cattle enterprise for a large farm, 1973

Item	Unit	Amount	
(1) Gross returns			
Beef	kg/a-u	90.00	
	Cr$	539.10	
Milk	l/a-u	213.60	
	Cr$	173.02	
Total	Cr$		712.12
(2) Total operating costs[a]	Cr$		375.72
(3) Annual investment costs[b]	Cr$		476.00
(4) Labor			
Jan/Feb	m/d[c]	0.28	
Mar/Apr	m/d	0.28	
May/June	m/d	0.42	
July/Aug	m/d	0.42	
Sep/Oct	m/d	0.42	
Nov/Dec	m/d	0.42	
Total	m/d		2.24
(5) Land			
Pasture	ha	3.53	
Elephantgrass	ha	0.07	
Palma	ha	0.02	
Total	ha		3.25
(6) Gross margin	Cr$		336.40
Expected gross margin	Cr$		245.47

[a]Includes expenses with feed, salt, vaccines, etc.

[b]Includes expenses with fences, mineral boxes, etc.

[c]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976] and Table D-5.

Table B-16. Gross returns, costs, and resource requirements for the production of one hectare of elephantgrass, 1973

Item	Unit		Amount
(1) Gross returns[a]	kg/ha		12,820.80
	Cr$		1,282.08
(2) Total operating costs	Cr$		54.97
(3) Labor			
Jan/Feb	m/d[b]	4.83	
Mar/Apr	m/d	4.99	
May/June	m/d	7.00	
July/Aug	m/d	7.00	
Sep/Oct	m/d	7.00	
Nov/Dec	m/d	7.00	
Total	m/d		37.82
(4) Gross margin	Cr$		1,227.11

[a]Fresh material.

[b]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENT, 1976].

Table B-17. Gross returns, costs, and resource requirements for the production of one hectare of palma, 1973

Item	Unit		Amount
(1) Gross returns	kg/ha		5,970.00
	Cr$		179.10
(2) Total operating costs	Cr$		27.75
(3) Labor			
Jan/Feb	m/d[a]	11.45	
Mar/Apr	m/d	1.11	
May/June	m/d	7.32	
July/Aug	m/d	7.32	
Sep/Oct	m/d	7.32	
Nov/Dec	m/d	7.32	
Total	m/d		41.84
(4) Gross margin	Cr$		151.35

[a]m/d is man per day.

SOURCE: SUDENE/World Bank Farm Survey [SUDENE, 1976].

APPENDIX C
MATRICES OF COEFFICIENTS AND STRUCTURE OF LINEAR PROGRAMMING MODELS

Table C-1. Code key of row elements for the sharecropper's basic matrix of the programming model

Row codes	Explanation	Unit
TPCOTT	Total product balance for cotton	Hectare
TPCOT1	Total product balance for cotton 1	Hectare
TPCOT3	Total product balance for cotton 3	Hectare
TPBEA1	Total product balance for beans 1	Hectare
TPBEA3	Total product balance for beans 3	Hectare
TPCORN	Total product balance for corn	Hectare
TPCOR1	Total product balance for corn 1	Hectare
TPCASS	Total product balance for cassava	Hectare
BACOTT	Commodity balance for cotton	Hectare
BACOT1	Commodity balance for cotton 1	Hectare
BACOT3	Commodity balance for cotton 3	Hectare
BABEA1	Commodity balance for beans 1	Hectare
BABEA3	Commodity balance for beans 3	Hectare
BACORN	Commodity balance for corn	Hectare
BACOR1	Commodity balance for corn 1	Hectare
BACASS	Commodity balance for cassava	Hectare
BECONS	Minimum consumption level of beans for the sharecropper's family	Hectare
COCONS	Minimum consumption level of corn for the sharecropper's family	Hectare
CACONS	Minimum consumption level of cassave for the sharecropper's family	Hectare
CROPLA	Cropland	Hectare

Table C-1. Continued

Row codes	Explanation	Unit
FALAB1	Family labor constraint in Jan/Feb	Man/days
FALAB2	Family labor constraint in Mar/Apr	Man/days
FALAB3	Family labor constraint in May/June	Man/days
FALAB4	Family labor constraint in July/Aug	Man/days
FALAB5	Family labor constraint in Sep/Oct	Man/days
FALAB6	Family labor constraint in Nov/Dec	Man/days
LABCON	Temporary labor constraint in Mar/Apr	Man/days
SULAB1	_Sujeicão_ labor in Jan/Feb	Man/days
SULAB2	_Sujeicão_ labor in Mar/Apr	Man/days
SULAB3	_Sujeicão_ labor in May/June	Man/days
SULAB4	_Sujeicão_ labor in July/Aug	Man/days
SULAB5	_Sujeicão_ labor in Sep/Oct	Man/days
SULAB6	_Sujeicão_ labor in Nov/Dec	Man/days
OPCAPI	Available operating capital	Cruzeiros

Table C-2. Code key of row elements for the landowner's basic matrix of the programming models

Row codes	Explanation	Unit
CROPLA	Cropland type "A"	Hectare
CROPLB	Cropland type "B"	Hectare
PASTUR	Pasture land	Hectare
FALLOW	Fallow land	Hectare
SHLAND	Sharecropped land	Hectare
SHARBA	Sharecropped land balance	Hectare
PALMA	Forage balance for palma	Hectare
ELEPHA	Forage balance for elephantgrass	Hectare
LABL01	Labor available to the landowner in Jan/Feb	Man/days
LABL02	Labor available to the landowner in Mar/Apr	Man/days
LABL03	Labor available to the landowner in May/June	Man/days
LABL04	Labor available to the landowner in July/Aug	Man/days
LABL05	Labor available to the landowner in Sep/Oct	Man/days
LABL06	Labor available to the landowner in Nov/Dec	Man/days
LABSH1	Labor available to the sharecropper in Jan/Feb	Man/days
LABSH2	Labor available to the sharecropper in Mar/Apr	Man/days
LABSH3	Labor available to the sharecropper in May/June	Man/days
LABSH4	Labor available to the sharecropper in July/Aug	Man/days
LABSH5	Labor available to the sharecropper in Sep/Oct	Man/days
LABSH6	Labor available to the sharecropper in Nov/Dec	Man/days
LABCON	Temporary labor constraint in Mar/Apr	Man/days

Table C-2. Continued

Row codes	Explanation	Unit
FALAB1	Family labor constraint in Jan/Feb	Man/days
FALAB2	Family labor constraint in Mar/Apr	Man/days
FALAB3	Family labor constraint in May/June	Man/days
FALAB4	Family labor constraint in July/Aug	Man/days
FALAB5	Family labor constraint in Sep/Oct	Man/days
FALAB6	Family labor constraint in Nov/Dec	Man/days
PELAB1	Permanent labor constraint in Jan/Feb	Man/days
PELAB2	Permanent labor constraint in Mar/Apr	Man/days
PELAB3	Permanent labor constraint in May/June	Man/days
PELAB4	Permanent labor constraint in July/Aug	Man/days
PELAB5	Permanent labor constraint in Sep/Oct	Man/days
PELAB6	Permanent labor constraint in Nov/Dec	Man/days
SULAB1	Sharecropper labor in Jan/Feb	Man/days
SULAB2	Sharecropper labor in Mar/Apr	Man/days
SULAB3	Sharecropper labor in May/June	Man/days
SULAB4	Sharecropper labor in July/Aug	Man/days
SULAB5	Sharecropper labor in Sep/Oct	Man/days
SULAB6	Sharecropper labor in Nov/Dec	Man/days
OPCAPI	Operating capital borrowing limit	Cruzeiros
INVCAP	Investment capital borrowing limit	Cruzeiros
CREDLI	Credit capacity limit	Cruzeiros
OPCAPN	Available operating capital	Cruzeiros
INCAPN	Available investment capital	Cruzeiros

Table C-3. Code key for column activities of the sharecropper's basic matrix of the programming model

Code	Explanation	Unit
SC1	Cotton	Hectare
SC2	Corn	Hectare
SC3	Cassava	Hectare
SC4	Cotton/beans/corn	Hectare
SC5	Cotton/beans	Hectare
TF1	Transfer of cotton from product balance to selling cotton activity	Kilogram
TF2	Transfer of cotton (1) from product balance to selling cotton activity (1)	Kilogram
TF3	Transfer of cotton (3) from product balance to selling cotton activity (3)	Kilogram
TF4	Transfer of beans (1) from product balance to selling cotton activity (1)	Kilogram
TF5	Transfer of beans (3) from product balance to selling cotton activity (3)	Kilogram
TF6	Transfer of corn from product balance to selling corn activity	Kilogram
TF7	Transfer of corn (1) from product balance to selling corn activity (1)	Kilogram
TF8	Transfer of cassava from product balance to selling cassava activity	Kilogram
LS1	Selling cotton activity	Hectare
LS2	Selling cotton (1) activity	Hectare
LS3	Selling cotton (3) activity	Hectare
LS4	Selling beans (1) activity	Hectare
LS5	Selling beans (3) activity	Hectare
LS6	Selling corn activity	Hectare
LS7	Selling corn (1) activity	Hectare

Table C-3. Continued

Code	Explanation	Unit
LS8	Selling cassava activity	Hectare
CB1	Consumption of beans produced by the SC4 activity	Kilogram
CB2	Consumption of beans produced by the SC5 activity	Kilogram
CC1	Consumption of corn produced by the SC2 activity	Kilogram
CC2	Consumption of corn produced by the SC4 activity	Kilogram
CM	Consumption of cassava produced by the SC5 activity	Kilogram
TL1	Temporary hired labor use in Jan/Feb	Man/days
TL2	Temporary hired labor use in Mar/Apr	Man/days
TL3	Temporary hired labor use in May/June	Man/days
TL4	Temporary hired labor use in July/Aug	Man/days
TL5	Temporary hired labor use in Sep/Oct	Man/days
TL6	Temporary hired labor use in Nov/Dec	Man/days
OL1	Operator's family work outside the farm in Jan/Feb	Man/days
OL2	Operator's family work outside the farm in Mar/Apr	Man/days
OL3	Operator's family work outside the farm in May/June	Man/days
OL4	Operator's family work outside the farm in July/Aug	Man/days
OL5	Operator's family work outside the farm in Sep/Oct	Man/days
OL6	Operator's family work outside the farm in Nov/Dec	Man/days
SL1	_Sujeicão_ labor in Jan/Feb	Man/days
SL2	_Sujeicão_ labor in Mar/Apr	Man/days
SL3	_Sujeicão_ labor in May/June	Man/days
SL4	_Sujeicão_ labor in July/Aug	Man/days

Table C-3. Continued

Code	Explanation	Unit
SL5	Sujeicão labor in Sep/Oct	Man/days
SL6	Sujeicão labor in Nov/Dec	Man/days

Table C-4. Code key for column activities of the landowner's basic matrix of the programming model

Code	Explanation	Unit
LC1	Cotton	Hectare
LC2	Rice	Hectare
LC3	Beans	Hectare
LC4	Corn	Hectare
LC5	Cassava	Hectare
LC6	Cotton/beans/corn	Hectare
LC7	Beans/corn	Hectare
LC8	Cotton/beans	Hectare
LC9	Cattle enterprises	Animal-unit
FO1	Palma	Hectare
FO2	Elephantgrass	Hectare
FL1	Family labor use, transferred to labor available to the landowner in Jan/Feb	Man/days
FL2	Family labor use, transferred to labor available to the landowner in Mar/Apr	Man/days
FL3	Family labor use, transferred to labor available to the landowner in May/June	Man/days
FL4	Family labor use, transferred to labor available to the landowner in July/Aug	Man/days
FL5	Family labor use, transferred to labor available to the landowner in Sep/Oct	Man/days
FL6	Family labor use, transferred to labor available to the landowner in Nov/Dec	Man/days
TL1	Temporary hired labor use in Jan/Feb	Man/days
TL2	Temporary hired labor use in Mar/Apr	Man/days
TL3	Temporary hired labor use in May/June	Man/days

Table C-4. Continued

Code	Explanation	Unit
TL4	Temporary hired labor use in July/Aug	Man/days
TL5	Temporary hired labor use in Sep/Oct	Man/days
TL6	Temporary hired labor use in Nov/Dec	Man/days
SL1	Sharecropper labor use, transferred to labor available to the landowner in Jan/Feb	Man/days
SL2	Sharecropper labor use, transferred to labor available to the landowner in Mar/Apr	Man/days
SL3	Sharecropper labor use, transferred to labor available to the landowner in May/June	Man/days
SL4	Sharecropper labor use, transferred to labor available to the landowner in July/Aug	Man/days
SL5	Sharecropper labor use, transferred to labor available to the landowner in Sep/Oct	Man/days
SL6	Sharecropper labor use, transferred to labor available to the landowner in Nov/Dec	Man/days
PL1	Permanent labor use in Jan/Feb	Man/days
PL2	Permanent labor use in Mar/Apr	Man/days
PL3	Permanent labor use in May/June	Man/days
PL4	Permanent labor use in July/Aug	Man/days
PL5	Permanent labor use in Sep/Oct	Man/days
PL6	Permanent labor use in Nov/Dec	Man/days
NS	Number of sharecroppers	---
BO1	Borrowing operating capital 1	Cruzeiros
BO2	Borrowing operating capital 2	Cruzeiros
BI1	Borrowing investment capital 1	Cruzeiros
BI2	Borrowing investment capital 2	Cruzeiros

Table C-4. Continued

Code	Explanation	Unit
IP	Improved pasture land	Hectare
IF	Improved fallow land	Hectare
SLS	Sharecropped land supply transferred to sharecropped land constraint	Hectare
SC	Crop enterprises produced in the sharecropped part of the farm	Hectare
SIL2	Temporary hired labor in Mar/Apr hired for the sharecropped part of the farm	Hectare

Table C-5. Matrix of coefficients for the sharecropper sub-model


```
//   EXEC   MPS
         PROGRAM
         INITIALZ
         TITLE('SHARECROPPER ECONOMY')
         MOVE(XDATA,'SET1')
         MOVE(XPBNAME,'SUDENE')
         CONVERT ('SUMMARY')
         BCDOUT
         SETUP('MAX')
         MOVE(XOBJ,'OBJ')
         MOVE(XRHS,'Z1')
         PICTURE
         PRIMAL
         SOLUTION
         TRANCOL
         RANGE
         EXIT
         PEND
//PROBLEM.SYSIN DD *
NAME           SET1
ROWS
 N   OBJ
 G   TPCOTT
 G   TPCOT1
 G   TPCOT3
 G   TPBEA1
 G   TPBEA3
 G   TPCORN
 G   TPCOR1
 G   TPCASS
 E   BACOTT
 E   BACOT1
 E   BACOT3
 E   BABEA1
 E   BABEA3
 E   BACORN
 E   BACOR1
 E   BACASS
 G   BECONS
 G   COCONS
 G   CACONS
 E   CRCPLA
 L   FALAB1
 L   FALAB2
 L   FALAB3
```

Table C-5. Continued

09 NOVEMBER 1978 NERDC --- CARD LIST UTILITY

```
 L   FALAB4
 L   FALAB5
 L   FALAB6
 L   LABCON
 L   SULAB1
 L   SULAB2
 L   SULAB3
 L   SULAB4
 L   SULAB5
 L   SULAB6
 L   OPCAPI
COLUMNS
    SC1       OBJ          -0.16   TPCOTT      201.26
    SC1       CROPLA        1.00   FALAB1        0.58
    SC1       FALAB2        9.08   FALAB3        5.20
    SC1       FALAB4        1.09   FALAB5        7.61
    SC1       FALAB6        4.34   OPCAPI        0.16
    SC2       OBJ          -0.44   TPCORN      427.17
    SC2       CROPLA        1.00   FALAB1        6.96
    SC2       FALAB2       27.93   FALAB3        9.78
    SC2       FALAB4        5.60   FALAB5        2.24
    SC2       FALAB6        2.24   OPCAPI        0.44
    SC3       OBJ         -63.50   TPCASS     3985.94
    SC3       CROPLA        1.00   FALAB1       10.37
    SC3       FALAB2       21.10   FALAB3       19.77
    SC3       FALAB4        3.94   FALAB5        3.95
    SC3       FALAB6        5.75   OPCAPI       63.50
    SC4       OBJ          -1.38   TPCOT1      156.83
    SC4       TPBEA1      124.85   TPCOR1      280.01
    SC4       CROPLA        1.00   FALAB1        5.17
    SC4       FALAB2       26.24   FALAB3        8.56
    SC4       FALAB4        5.88   FALAB5        7.05
    SC4       FALAB6        4.70   OPCAPI        1.38
    SC5       OBJ          -1.66   TPCOT3      157.00
    SC5       TPBEA3      129.25   CROPLA        1.00
    SC5       FALAB1        3.43   FALAB2       23.98
    SC5       FALAB3        8.59   FALAB4        4.80
    SC5       FALAB5        7.20   FALAB6        4.80
    SC5       OPCAPI        1.66
    TF1       TPCOTT       -1.00   BACOTT        1.00
    TF2       TPCOT1       -1.00   BACOT1        1.00
    TF3       TPCOT3       -1.00   BACOT3        1.00
    TF4       TPBEA1       -1.00   BABEA1        1.00
    TF5       TPBEA3       -1.00   BABEA3        1.00
    TF6       TPCORN       -1.00   BACORN        1.00
```

Table C-5. Continued

09 NOVEMBER 1978			NERDC --- CARD LIST UTILITY	
TF7	TPCOR1	-1.00	BACOR1	1.00
TF8	TPCASS	-1.00	BACASS	1.00
SS1	OBJ	169.06	BACOTT	-201.25
SS2	OBJ	131.74	BACOT1	-156.83
SS3	OBJ	131.88	BACOT3	-157.00
SS4	OBJ	174.79	BABEA1	-124.85
SS5	OBJ	180.95	BABEA3	-129.25
SS6	OBJ	149.51	BACORN	-427.17
SS7	OBJ	98.00	BACOR1	-280.01
SS8	OBJ	279.01	BACASS	-3985.94
CB1	BABEA1	-1.00	BECONS	1.00
CB2	BABEA3	-1.00	BECONS	1.00
CC1	BACORN	-1.00	COCONS	1.00
CC2	BACOR1	-1.00	COCONS	1.00
CM	BACASS	-1.00	CACONS	1.00
TL1	OBJ	-3.50	FALAB1	-1.00
TL1	OPCAPI	3.50		
TL2	OBJ	-3.50	FALAB2	-1.00
TL2	LABCON	1.00	OPCAPI	3.50
TL3	OBJ	-3.50	FALAB3	-1.00
TL3	OPCAPI	3.50		
TL4	OBJ	-3.50	FALAB4	-1.00
TL4	OPCAPI	3.50		
TL5	OBJ	-3.50	FALAB5	-1.00
TL5	OPCAPI	3.50		
TL6	OBJ	-3.50	FALAB6	-1.00
TL6	OPCAPI	3.50		
OL1	OBJ	6.00	FALAB1	1.00
OL2	OBJ	6.00	FALAB2	1.00
OL3	OBJ	6.00	FALAB3	1.00
OL4	OBJ	6.00	FALAB4	1.00
OL5	OBJ	6.00	FALAB5	1.00
OL6	OBJ	6.00	FALAB6	1.00
SL1	OBJ	4.00	SULAB1	1.00
SL2	OBJ	4.00	SULAB2	1.00
SL3	OBJ	4.00	SULAB3	1.00
SL4	OBJ	4.00	SULAB4	1.00
SL5	OBJ	4.00	SULAB5	1.00
SL6	OBJ	4.00	SULAB6	1.00
RHS				
Z1	BECONS	185.04	COCONS	62.90
Z1	CACONS	578.45	CROPLA	10.00
Z1	FALAB1	90.93	FALAB2	90.93
Z1	FALAB3	90.93	FALAB4	90.93
Z1	FALAB5	90.93	FALAB6	90.93

Table C-5. Continued

09 NOVEMBER 1978			NERDC --- CARD LIST UTILITY	
Z1	LABCON	171.00		
Z1	SULAB1	19.07	SULAB2	19.07
Z1	SULAB3	19.07	SULAB4	19.07
Z1	SULAB5	19.07	SULAB6	19.07
Z1	OPCAPI	810.80		
ENDATA				

Table C-6. Structure of the sharecropper linear programming model

		LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	FL1	FL2	FL3	FL4	FL5	FL6
OBJ	N	C	D	C	C	C	C	C	C	C						
CRCPLA	L		1	1				1								
CRCPLE	L	1			1	1	1		1							
PASTUR	L									T						
FALLOW	L															
LABLC1	L	T	B	A	A	B	A	A	A	T	-1					
LABLC2	L	A	B	A	B	B	B	A	B	T		-1				
LABLC3	L	A	B	A	A	B	A	A	A	T			-1			
LABLC4	L	A	B	B	A	A	A	B	A	T				-1		
LABLC5	L	A		A	A	A	A	A	A	T					-1	
LABLC6	L	A	A	A	A	A	A	A	A	T						-1
LABCON	L															
FALAB1	L										1					
FALAB2	L											1				
FALAB3	L												1			
FALAB4	L													1		
FALAB5	L														1	
FALAB6	L															1
PELAB1	L															
PELAB2	L															
PELAB3	L															
PELAB4	L															
PELAB5	L															
PELAB6	L															
LPCAPI	L															
INVCAP	L															
CREDLI	L															
CPCAPN	L	T	A	B	T	C	A	A	A	C						
INVCAN	L									C						

	TL1	TL2	TL3	TL4	TL5	TL6	PL1	PL2	PL3	PL4	PL5	PL6
OBJ	-A	-A	-A	-A	-A	-A	-A	-A	-A	-A	-A	-A
CRCPLA												
CRCPLE												
PASTUR												
FALLOW												
LABLC1	-1						-1					
LABLC2		-1						-1				
LABLC3			-1						-1			
LABLC4				-1						-1		
LABLC5					-1						-1	
LABLC6						-1						-1
LABCON		1										
FALAB1												
FALAB2												
FALAB3												
FALAB4												
FALAB5												
FALAB6												
PELAB1							1					
PELAB2								1				
PELAB3									1			
PELAB4										1		
PELAB5											1	
PELAB6												1
LPCAPI												
INVCAP												
CREDLI												
CPCAPN	A	A	A	A	A	A	A	A	A	A	A	A
INVCAN												

	OL1	OL2	OL3	OL4	OL5	OL6	BO1	BO2	BI1	BI2	IP	IF	Z1
OBJ	A	A	A	A	A	A	-U	-T	-U	-T	-A	-A	
CRCPLA													T
CRCPLE											-1		A
PASTUR											1	-1	A
FALLOW												1	A
LABLC1													
LABLC2													
LABLC3													
LABLC4													
LABLC5											A	A	
LABLC6											E	B	
LABCON													B
FALAB1	1												B
FALAB2		1											B
FALAB3			1										B
FALAB4				1									B
FALAB5					1								B
FALAB6						1							B
PELAB1													A
PELAB2													A
PELAB3													A
PELAB4													A
PELAB5													A
PELAB6													A
LPCAPI							1						T
INVCAP									1				E
CREDLI							1	1	1	1			T
CPCAPN							-1	-1			A	A	
INVCAN									-1	-1			

Table C-7. Matrix of coefficients for the small landowner model

09 NOVEMBER 1978 NERDC --- CARD LIST UTILITY

```
// EXEC MPS
          PROGRAM
          TITLE('LANDLORD ECONOMY')
          INITIALZ
          MOVE(XDATA,'SET1')
          MOVE(XPBNAME,'SUDENE')
          CONVERT ('SUMMARY')
          BCDOUT
          SETUP('MAX')
          MOVE(XOBJ,'OBJ')
          MOVE(XRHS,'Z1')
          TRANCOL
          PICTURE
          PRIMAL
          SOLUTION
          TRANCOL
          RANGE
          EXIT
          PEND
//PROBLEM.SYSIN DD *
NAME          SET1
ROWS
 N  OBJ
 L  CROPLA
 L  CROPLB
 L  PASTUR
 L  FALLOW
 L  LABL01
 L  LABL02
 L  LABL03
 L  LABL04
 L  LABL05
 L  LABL06
 L  LABCON
 L  FALAB1
 L  FALAB2
 L  FALAB3
 L  FALAB4
 L  FALAB5
 L  FALAB6
 L  PELAB1
 L  PELAB2
 L  PELAB3
 L  PELAB4
 L  PELAB5
```

Table C-7. Continued

09 NOVEMBER 1978 NERDC --- CARD LIST UTILITY

L PELAB6
L OPCAPI
L INVCAP
L CREDLI
L OPCAPN
L INVCAN
COLUMNS

LC1	OBJ	402.19	CROPLB	1.00
LC1	LABL01	0.58	LABL02	9.08
LC1	LABL03	5.20	LABL04	1.09
LC1	LABL05	7.61	LABL06	4.34
LC1	OPCAPN	0.33		
LC2	OBJ	1808.02	CROPLA	1.00
LC2	LABL01	43.47	LABL02	45.43
LC2	LABL03	16.47	LABL04	15.00
LC2	LABL06	8.44	OPCAPN	2.24
LC3	OBJ	669.26	CROPLA	1.00
LC3	LABL01	5.58	LABL02	2.23
LC3	LABL03	4.64	LABL04	29.49
LC3	LABL05	6.32	LABL06	4.46
LC3	OPCAPN	22.78		
LC4	OBJ	212.70	CROPLB	1.00
LC4	LABL01	6.96	LABL02	27.93
LC4	LABL03	9.78	LABL04	5.60
LC4	LABL05	2.24	LABL06	2.24
LC4	OPCAPN	0.89		
LC5	OBJ	271.60	CROPLB	1.00
LC5	LABL01	10.37	LABL02	21.10
LC5	LABL03	19.77	LABL04	3.94
LC5	LABL05	3.95	LABL06	5.75
LC5	OPCAPN	126.99		
LC6	OBJ	700.61	CROPLB	1.00
LC6	LABL01	5.17	LABL02	26.24
LC6	LABL03	8.56	LABL04	5.88
LC6	LABL05	7.05	LABL06	4.70
LC6	OPCAPN	2.75		
LC7	OBJ	578.01	CROPLA	1.00
LC7	LABL01	7.75	LABL02	3.10
LC7	LABL03	5.24	LABL04	36.96
LC7	LABL05	8.63	LABL06	6.20
LC7	OPCAPN	6.17		
LC8	OBJ	569.18	CROPLB	1.00
LC8	LABL01	3.43	LABL02	23.98
LC8	LABL03	8.59	LABL04	4.80
LC8	LABL05	7.20	LABL06	4.80

Table C-7. Continued

09 NOVEMBER 1978			NERDC --- CARD LIST UTILITY	
LC8	OPCAPN	3.32		
LC9	OBJ	312.09	PASTUR	0.75
LC9	LABL01	0.25	LABL02	0.25
LC9	LABL03	0.38	LABL04	0.38
LC9	LABL05	0.38	LABL06	0.38
LC9	OPCAPN	121.70	INVCAN	176.00
FL1	LABL01	-1.00	FALAB1	1.00
FL2	LABL02	-1.00	FALAB2	1.00
FL3	LABL03	-1.00	FALAB3	1.00
FL4	LABL04	-1.00	FALAB4	1.00
FL5	LABL05	-1.00	FALAB5	1.00
FL6	LABLC6	-1.00	FALAB6	1.00
TL1	OBJ	-7.00	LABL01	-1.00
TL1	OPCAPN	7.00		
TL2	OBJ	-7.00	LABL02	-1.00
TL2	LABCON	1.00	OPCAPN	7.00
TL3	OBJ	-7.00	LABL03	-1.00
TL3	OPCAPN	7.00		
TL4	OBJ	-7.00	LABL04	-1.00
TL4	OPCAPN	7.00		
TL5	OBJ	-7.00	LABL05	-1.00
TL5	OPCAPN	7.00		
TL6	OBJ	-7.00	LABL06	-1.00
TL6	OPCAPN	7.00		
PL1	OBJ	-6.00	LABL01	-1.00
PL1	PELAB1	1.00	OPCAPN	6.00
PL2	OBJ	-6.00	LABL02	-1.00
PL2	PELAB2	1.00	OPCAPN	6.00
PL3	OBJ	-6.00	LABL03	-1.00
PL3	PELAB3	1.00	OPCAPN	6.00
PL4	OBJ	-6.00	LABL04	-1.00
PL4	PELAB4	1.00	OPCAPN	6.00
PL5	OBJ	-6.00	LABL05	-1.00
PL5	PELAB5	1.00	OPCAPN	6.00
PL6	OBJ	-6.00	LABL06	-1.00
PL6	PELAB6	1.00	OPCAPN	6.00
OL1	OBJ	6.00	FALAB1	1.00
OL2	OBJ	6.00	FALAB2	1.00
OL3	OBJ	6.00	FALAB3	1.00
OL4	OBJ	6.00	FALAB4	1.00
OL5	OBJ	6.00	FALAB5	1.00
OL6	OBJ	6.00	FALAB6	1.00
BO1	OBJ	-0.10	CREDLI	1.00
BO1	OPCAPI	1.00	OPCAPN	-1.00
BO2	OBJ	-0.15	CREDLI	1.00

Table C-7. Continued

	09 NOVEMBER 1978		NERDC --- CARD LIST UTILITY		
	BO2	OPCAPN	-1.00		
	BI1	OBJ	-0.10	CREDLI	1.00
	BI1	INVCAP	1.00	INVCAN	-1.00
	BI2	OBJ	-0.15	CREDLI	1.00
	BI2	INVCAN	-1.00		
	IP	OBJ	-2.25	CROPLB	-1.00
	IP	PASTUR	1.00	LABL05	5.81
	IP	LABL06	12.75	OPCAPN	2.25
	IF	OBJ	-3.75	PASTUR	-1.00
	IF	FALLOW	1.00	LABL05	6.34
	IF	LABL06	13.07	OPCAPN	5.75
RHS					
	Z1	CROPLA	0.86	CROPLB	2.75
	Z1	PASTUR	7.43	FALLOW	3.22
	Z1	FALAB1	36.17		
	Z1	FALAB2	36.17	FALAB3	36.17
	Z1	FALAB4	36.17	FALAB5	36.17
	Z1	FALAB6	36.17	LABCON	85.00
	Z1	PELAB1	6.25		
	Z1	PELAB2	6.25	PELAB3	6.25
	Z1	PELAB4	6.25	PELAB5	6.25
	Z1	PELAB6	6.25	OPCAPI	15600.00
	Z1	INVCAP	15600.00	CREDLI	17795.79
ENDATA					

Table C-8. Structure of the small landowner linear programming model

		LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	FL1	FL2	FL3	FL4	FL5	FL6	TL1	TL2	TL3	TL4	TL5	TL6	PL1	PL2	PL3	PL4	PL5	PL6	OL1	OL2	OL3	OL4	OL5	OL6	RO1	RO2	BI1	BI2	IP	IF	Z1
OBJ	N	C	D	C	C	C	C	C	C	C							A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	U	T	U	T	A	A	
CRCPLA	L		1	1				1																																	T
CRCPLB	L	1			1	1	1		1																														-1		A
PASTUR	L									T																													1	-1	A
FALLCA	L																																							1	A
LABLO1	L	T	B	A	A	B	A	A	A	T	-1						-1						-1																		
LABLC2	L	A	B	A	B	B	B	A	B	T		-1						-1						-1																	
LABLC3	L	A	B	A	A	B	A	A	A	T			-1						-1						-1																
LABLO4	L	A	B	B	A	A	A	B	A	T				-1						-1						-1															
LABLC5	L	A		A	A	A	A	A	A	T					-1						-1						-1												A	A	
LABLC6	L	A	A	A	A	A	A	A	A	T						-1						-1						-1											B	B	
LABCCN	L																	1																							B
FALAB1	L										1																		1												B
FALAB2	L											1																		1											B
FALAB3	L												1																		1										B
FALAB4	L													1																		1									B
FALAB5	L														1																		1								B
FALAB6	L															1																		1							B
PELAB1	L																						1																		A
PELAB2	L																							1																	A
PELAB3	L																								1																A
PELAB4	L																									1															A
PELAB5	L																										1														A
PELAB6	L																											1													A
CRCAPI	L																																		1						E
INVCAP	L																																				1				E
CREDLI	L																																		1	1	1	1			E
CRCAPN	L	T	A	B	T	C	A	A	A	C							A	A	A	A	A	A	A	A	A	A	A	A							-1	-1			A	A	E
INVCAN	L									C																											-1	-1			

Table C-9. Matrix of coefficients for the medium landowner model

09 NOVEMBER 1978 NERDC --- CARD LIST UTILITY

```
// EXEC MPS
          PROGRAM
          TITLE('LANDLORD ECONOMY')
          INITIALZ
          MOVE(XDATA,'SET1')
          MOVE(XPBNAME,'SUDENE')
          CONVERT ('SUMMARY')
          BCDOUT
          SETUP('MAX')
          MOVE(XOBJ,'OBJ')
          MOVE(XRHS,'Z2')
          TRANCOL
          PICTURE
          PRIMAL
          SOLUTION
          TRANCOL
          RANGE
          EXIT
          PEND
//PROBLEM.SYSIN DD *
NAME          SET1
ROWS
 N  OBJ
 L  CROPLA
 L  CROPLB
 L  PASTUR
 L  FALLOW
 E  SHLAND
 E  SHARBA
 L  ELEPHA
 L  PALMA
 L  LABL01
 L  LABL02
 L  LABL03
 L  LABL04
 L  LABL05
 L  LABL06
 L  LABSH1
 L  LABSH2
 L  LABSH3
 L  LABSH4
 L  LABSH5
 L  LABSH6
 L  LABCON
 L  FALAB1
```

Table C-9. Continued


```
 L   FALAB2
 L   FALAB3
 L   FALAB4
 L   FALAB5
 L   FALAB6
 L   PELAB1
 L   PELAB2
 L   PELAB3
 L   PELAB4
 L   PELAB5
 L   PELAB6
 L   SULAB1
 L   SULAB2
 L   SULAB3
 L   SULAB4
 L   SULAB5
 L   SULAB6
 L   OPCAPI
 L   INVCAP
 L   CREDLI
 L   OPCAPN
 L   INVCAN
COLUMNS
    LC1       OBJ           402.19   CROPLB        1.00
    LC1       LABL01          0.58   LABL02        9.08
    LC1       LABL03          5.20   LABL04        1.09
    LC1       LABL05          7.61   LABL06        4.34
    LC1       OPCAPN          0.33
    LC2       OBJ          1808.02   CROPLA        1.00
    LC2       LABL01         43.47   LABL02       45.43
    LC2       LABL03         16.47   LABL04       15.00
    LC2       LABL06          8.44   OPCAPN        2.24
    LC3       OBJ           669.26   CROPLA        1.00
    LC3       LABL01          5.58   LABL02        2.23
    LC3       LABL03          4.64   LABL04       29.49
    LC3       LABL05          6.32   LABL06        4.46
    LC3       OPCAPN         22.78
    LC4       OBJ           212.70   CROPLB        1.00
    LC4       LABL01          6.96   LABL02       27.93
    LC4       LABL03          9.78   LABL04        5.60
    LC4       LABL05          2.24   LABL06        2.24
    LC4       OPCAPN          0.89
    LC5       OBJ           271.60   CROPLB        1.00
    LC5       LABL01         10.37   LABL02       21.10
    LC5       LABL03         19.77   LABL04        3.94
```

Table C-9. Continued

09 NOVEMBER 1978 NERDC --- CARD LIST UTILITY

LC5	LABLO5	3.95	LABLO6	5.75
LC5	OPCAPN	126.99		
LC6	OBJ	700.61	CROPLB	1.00
LC6	LABLO1	5.17	LABLO2	26.24
LC6	LABLO3	8.56	LABLO4	5.88
LC6	LABLO5	7.05	LABLO6	4.70
LC6	OPCAPN	2.75		
LC7	OBJ	578.01	CROPLA	1.00
LC7	LABLO1	7.75	LABLO2	3.10
LC7	LABLO3	5.24	LABLO4	36.96
LC7	LABLO5	8.63	LABLO6	6.20
LC7	OPCAPN	6.17		
LC8	OBJ	569.18	CROPLB	1.00
LC8	LABLO1	3.43	LABLO2	23.98
LC8	LABLO3	8.59	LABLO4	4.80
LC8	LABLO5	7.20	LABLO6	4.80
LC8	OPCAPN	3.32		
LC9	OBJ	321.50	PASTUR	3.11
LC9	ELEPHA	0.05	PALMA	0.01
LC9	LABLO1	0.26	LABLO2	0.26
LC9	LABLO3	0.40	LABLO4	0.40
LC9	LABLO5	0.40	LABLO6	0.40
LC9	OPCAPN	321.08	INVCAN	432.00
FO1	CROPLB	1.00	ELEPHA	-1.00
FO1	LABLO1	4.83	LABLO2	4.99
FO1	LABLO3	7.00	LABLO4	7.00
FO1	LABLO5	7.00	LABLO6	7.00
FO1	OPCAPN	54.97		
FO2	CROPLB	1.00	PALMA	-1.00
FO2	LABLO1	11.45	LABLO2	1.11
FO2	LABLO3	7.32	LABLO4	7.32
FO2	LABLO5	7.32	LABLO6	7.32
FO2	OPCAPN	27.75		
FL1	LABLO1	-1.00	FALAB1	1.00
FL2	LABLO2	-1.00	FALAB2	1.00
FL3	LABLO3	-1.00	FALAB3	1.00
FL4	LABLO4	-1.00	FALAB4	1.00
FL5	LABLO5	-1.00	FALAB5	1.00
FL6	LABLO6	-1.00	FALAB6	1.00
TL1	OBJ	-7.00	LABLO1	-1.00
TL1	OPCAPN	7.00		
TL2	OBJ	-7.00	LABLO2	-1.00
TL2	LABCON	1.00	OPCAPN	7.00
TL3	OBJ	-7.00	LABLO3	-1.00
TL3	OPCAPN	7.00		

Table C-9. Continued

09 NOVEMBER 1978			NERDC --- CARD LIST UTILITY	
TL4	OBJ	-7.00	LABL04	-1.00
TL4	OPCAPN	7.00		
TL5	OBJ	-7.00	LABL05	-1.00
TL5	OPCAPN	7.00		
TL6	OBJ	-7.00	LABL06	-1.00
TL6	OPCAPN	7.00		
PL1	OBJ	-6.00	LABL01	-1.00
PL1	PELAB1	1.00	OPCAPN	6.00
PL2	OBJ	-6.00	LABL02	-1.00
PL2	PELAB2	1.00	OPCAPN	6.00
PL3	OBJ	-6.00	LABL03	-1.00
PL3	PELAB3	1.00	OPCAPN	6.00
PL4	OBJ	-6.00	LABL04	-1.00
PL4	PELAB4	1.00	OPCAPN	6.00
PL5	OBJ	-6.00	LABL05	-1.00
PL5	PELAB5	1.00	OPCAPN	6.00
PL6	OBJ	-6.00	LABL06	-1.00
PL6	PELAB6	1.00	OPCAPN	6.00
SL1	OBJ	-4.00	LABL01	-1.00
SL1	SULAB1	1.00	OPCAPN	4.00
SL2	OBJ	-4.00	LABL02	-1.00
SL2	SULAB2	1.00	OPCAPN	4.00
SL3	OBJ	-4.00	LABL03	-1.00
SL3	SULAB3	1.00	OPCAPN	4.00
SL4	OBJ	-4.00	LABL04	-1.00
SL4	SULAB4	1.00	OPCAPN	4.00
SL5	OBJ	-4.00	LABL05	-1.00
SL5	SULAB5	1.00	OPCAPN	4.00
SL6	OBJ	-4.00	LABL06	-1.00
SL6	SULAB6	1.00	OPCAPN	4.00
NS	SHARBA	1.00	LABSH1	-90.93
NS	LABSH2	-90.93	LABSH3	-90.93
NS	LABSH4	-90.93	LABSH5	-90.93
NS	LABSH6	-90.93	SULAB1	-19.07
NS	SULAB2	-19.07	SULAB3	-19.07
NS	SULAB4	-19.07	SULAB5	-19.07
NS	SULAB6	-19.07		
BO1	OBJ	-0.10	CREDLI	1.00
BO1	CPCAPI	1.00	OPCAPN	-1.00
BO2	OBJ	-0.15	CREDLI	1.00
BO2	OPCAPN	-1.00		
BI1	OBJ	-0.10	CREDLI	1.00
BI1	INVCAP	1.00	INVCAN	-1.00
BI2	OBJ	-0.15	CREDLI	1.00
BI2	INVCAN	-1.00		

Table C-9. Continued

09 NOVEMBER 1978			NERDC --- CARD LIST UTILITY	
IP	OBJ	-2.25	CROPLB	-1.00
IP	PASTUR	1.00	LABLO5	5.81
IP	LABLO6	12.75	OPCAPN	2.25
IF	OBJ	-3.75	PASTUR	-1.00
IF	FALLOW	1.00	LABLO5	6.34
IF	LABLO6	13.07	OPCAPN	5.75
SLS	CROPLB	10.00	SHLAND	-10.00
SLS	SHARBA	-1.00		
SC	OBJ	1646.69	SHLAND	10.00
SC	LABSH1	52.45	LABSH2	261.65
SC	LABSH3	87.23	LABSH4	58.52
SC	LABSH5	70.05	LABSH6	47.15
SC	OPCAPN	1321.04		
STL2	OBJ	-3.50	LABSH2	-1.00
STL2	OPCAPN	3.50		
RHS				
Z2	CROPLA	1.73	CROPLB	16.63
Z2	PASTUR	67.51	FALLOW	19.09
Z2	LABCON	137.50	FALAB1	38.50
Z2	FALAB2	38.50	FALAB3	38.50
Z2	FALAB4	38.50	FALAB5	38.50
Z2	FALAB6	38.50	PELAB1	35.30
Z2	PELAB2	35.30	PELAB3	35.30
Z2	PELAB4	35.30	PELAB5	35.30
Z2	PELAB6	35.30	OPCAPI	15600.00
Z2	INVCAP	15600.00	CREDLI	52017.50
ENDATA				

Table C-10. Structure of the medium landowner linear programming model

		LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	FO1	FC2	FL1	FL2	FL3	FL4	FL5	FL6
OBJ	N	C	D	C	C	C	C	C	C	C								
CROPLA	L		1	1				1										
CROPLE	L	1			1	1	1		1		1	1						
PASTUR	L									A								
FALLOW	L																	
SHLAND	E																	
SHARBA	E																	
ELEPHA	L									U	-1							
PALVA	L									U		-1						
LABLC1	L	T	B	A	A	B	A	A	A	T	A	B	-1					
LABLC2	L	A	B	A	B	B	B	A	B	T	A	A		-1				
LABLC3	L	A	B	A	A	B	A	A	A	T	A	A			-1			
LABLC4	L	A	B	B	A	A	A	B	A	T	A	A				-1		
LABLC5	L	A		A	A	A	A	A	A	T	A	A					-1	
LABLC6	L	A	A	A	A	A	A	A	A	T	A	A						-1
LABSH1	L																	
LABSH2	L																	
LABSH3	L																	
LABSH4	L																	
LABSH5	L																	
LABSH6	L																	
LASCON	L																	
FALAB1	L												1					
FALAB2	L													1				
FALAB3	L														1			
FALAB4	L															1		
FALAB5	L																1	
FALAB6	L																	1
PELAB1	L																	
PELAB2	L																	
PELAB3	L																	
PELAB4	L																	
PELAB5	L																	
PELAB6	L																	
SULAB1	L																	
SULAB2	L																	
SULAB3	L																	
SULAB4	L																	
SULAB5	L																	
SULAB6	L																	
CFCAPI	L																	
INVCAP	L																	
CREDLI	L																	
CPCAFN	L	T	A	B	T	C	A	A	A	C	B	B						
INVCAN	L									C								

	TL1	TL2	TL3	TL4	TL5	TL6	PL1	PL2	PL3	PL4	PL5	PL6
OBJ	-A	-A	-A	-A	-A	-A	-A	-A	-A	-A	-A	-A
CROPLA												
CROPLE												
PASTUR												
FALLOW												
SHLAND												
SHARBA												
ELEPHA												
PALVA												
LABLC1	-1						-1					
LABLC2		-1						-1				
LABLC3			-1						-1			
LABLC4				-1						-1		
LABLC5					-1						-1	
LABLC6						-1						-1
LABSH1												
LABSH2												
LABSH3												
LABSH4												
LABSH5												
LABSH6												
LASCON		1										
FALAB1												
FALAB2												
FALAB3												
FALAB4												
FALAB5												
FALAB6												
PELAB1							1					
PELAB2								1				
PELAB3									1			
PELAB4										1		
PELAB5											1	
PELAB6												1
SULAB1												
SULAB2												
SULAB3												
SULAB4												
SULAB5												
SULAB6												
CFCAPI												
INVCAP												
CREDLI												
CPCAFN	A	A	A	A	A	A	A	A	A	A	A	A
INVCAN												

	SL1	SL2	SL3	SL4	SL5	SL6	NS	BO1	BO2	BI1	BI2	IP	IF	SLS	SC	STL2	Z3
OBJ	-A	-A	-A	-A	-A	-A		-U	-T	-U	-T	-A	-A		D	-A	
CROPLA																	A
CROPLE												-1		A			B
PASTUR												1	-1				C
FALLOW													1				C
SHLAND														-A	A		
SHARBA							1							-1			
ELEPHA																	
PALVA																	
LABLC1	-1																
LABLC2		-1															
LABLC3			-1														
LABLC4				-1													
LABLC5					-1							A	A				
LABLC6						-1						B	B				
LABSH1							-B								B		
LABSH2							-B								C	-1	
LABSH3							-B								B		
LABSH4							-B								B		
LABSH5							-B								B		
LABSH6							-B								B		
LASCON																	C
FALAB1																	D
FALAB2																	B
FALAB3																	B
FALAB4																	B
FALAB5																	B
FALAB6																	B
PELAB1																	B
PELAB2																	B
PELAB3																	D
PELAB4																	C
PELAB5																	B
PELAB6																	B
SULAB1	1						-B										
SULAB2		1					-B										
SULAB3			1				-B										
SULAB4				1			-B										
SULAB5					1		-B										
SULAB6						1	-B										
CFCAPI								1									E
INVCAP										1							E
CREDLI								1	1	1	1						F
CPCAFN	A	A	A	A	A	A		-1	-1			A	A		D	A	
INVCAN										-1	-1						

Table C-11. Matrix of coefficients for the large landowner sub-model

09 NOVEMBER 1978	NERDC --- CARD LIST UTILITY

```
// EXEC MPS
          PROGRAM
          TITLE('LANDLORD ECONOMY')
          INITIALZ
          MOVE(XDATA,'SET1')
          MOVE(XPBNAME,'SUDENE')
          CONVERT ('SUMMARY')
          BCDOUT
          SETUP('MAX')
          MOVE(XOBJ,'OBJ')
          MOVE(XRHS,'Z3')
          TRANCOL
          PICTURE
          PRIMAL
          SOLUTION
          TRANCOL
          RANGE
          EXIT
          PEND
//PROBLEM.SYSIN DD *
NAME           SET1
ROWS
 N  OBJ
 L  CROPLA
 L  CROPLB
 L  PASTUR
 L  FALLOW
 E  SHLAND
 E  SHARBA
 L  ELEPHA
 L  PALMA
 L  LABL01
 L  LABL02
 L  LABL03
 L  LABL04
 L  LABL05
 L  LABL06
 L  LABSH1
 L  LABSH2
 L  LABSH3
 L  LABSH4
 L  LABSH5
 L  LABSH6
 L  LABCON
 L  FALAB1
```

Table C-11. Continued

09 NOVEMBER 1978			NERDC --- CARD LIST UTILITY	
L FALAB2				
L FALAB3				
L FALAB4				
L FALAB5				
L FALAB6				
L PELAB1				
L PELAB2				
L PELAB3				
L PELAB4				
L PELAB5				
L PELAB6				
L SULAB1				
L SULAB2				
L SULAB3				
L SULAB4				
L SULAB5				
L SULAB6				
L OPCAPI				
L INVCAP				
L CREDLI				
L OPCAPN				
L INVCAN				
COLUMNS				
LC1	OBJ	402.19	CROPLB	1.00
LC1	LABL01	0.58	LABL02	9.08
LC1	LABL03	5.20	LABL04	1.09
LC1	LABL05	7.61	LABL06	4.34
LC1	OPCAPN	0.33		
LC2	OBJ	1808.02	CROPLA	1.00
LC2	LABL01	43.47	LABL02	45.43
LC2	LABL03	16.47	LABL04	15.00
LC2	LABL06	8.44	OPCAPN	2.24
LC3	OBJ	669.26	CROPLA	1.00
LC3	LABL01	5.58	LABL02	2.23
LC3	LABL03	4.64	LABL04	29.49
LC3	LABL05	6.32	LABL06	4.46
LC3	OPCAPN	22.78		
LC4	OBJ	212.70	CROPLB	1.00
LC4	LABL01	6.96	LABL02	27.93
LC4	LABL03	9.78	LABL04	5.60
LC4	LABL05	2.24	LABL06	2.24
LC4	OPCAPN	0.89		
LC5	OBJ	271.60	CROPLB	1.00
LC5	LABL01	10.37	LABL02	21.10
LC5	LABL03	19.77	LABL04	3.94

Table C-11. Continued

09 NOVEMBER 1978 NERDC --- CARD LIST UTILITY

LC5	LABL05	3.95	LABL06	5.75
LC5	OPCAPN	126.99		
LC6	OBJ	700.61	CROPLB	1.00
LC6	LABL01	5.17	LABL02	26.24
LC6	LABL03	8.56	LABL04	5.88
LC6	LABL05	7.05	LABL06	4.70
LC6	OPCAPN	2.75		
LC7	OBJ	578.01	CROPLA	1.00
LC7	LABL01	7.75	LABL02	3.10
LC7	LABL03	5.24	LABL04	36.96
LC7	LABL05	8.63	LABL06	6.20
LC7	OPCAPN	6.17		
LC8	OBJ	569.18	CROPLB	1.00
LC8	LABL01	3.43	LABL02	23.98
LC8	LABL03	8.59	LABL04	4.80
LC8	LABL05	7.20	LABL06	4.80
LC8	OPCAPN	3.32		
LC9	OBJ	336.40	PASTUR	3.53
LC9	ELEPHA	0.07	PALMA	0.02
LC9	LABL01	0.28	LABL02	0.28
LC9	LABL03	0.42	LABL04	0.42
LC9	LABL05	0.42	LABL06	0.42
LC9	OPCAPN	375.72	INVCAN	476.00
F01	CROPLB	1.00	ELEPHA	-1.00
F01	LABL01	4.83	LABL02	4.99
F01	LABL03	7.00	LABL04	7.00
F01	LABL05	7.00	LABL06	7.00
F01	OPCAPN	54.97		
F02	CROPLB	1.00	PALMA	-1.00
F02	LABL01	11.45	LABL02	1.11
F02	LABL03	7.32	LABL04	7.32
F02	LABL05	7.32	LABL06	7.32
F02	OPCAPN	27.75		
FL1	LABL01	-1.00	FALAB1	1.00
FL2	LABL02	-1.00	FALAB2	1.00
FL3	LABL03	-1.00	FALAB3	1.00
FL4	LABL04	-1.00	FALAB4	1.00
FL5	LABL05	-1.00	FALAB5	1.00
FL6	LABL06	-1.00	FALAB6	1.00
TL1	OBJ	-7.00	LABL01	-1.00
TL1	OPCAPN	7.00		
TL2	OBJ	-7.00	LABL02	-1.00
TL2	LABCON	1.00	OPCAPN	7.00
TL3	OBJ	-7.00	LABL03	-1.00
TL3	OPCAPN	7.00		

Table C-11. Continued

09 NOVEMBER 1978			NERDC --- CARD LIST UTILITY	
TL4	OBJ	-7.00	LABLO4	-1.00
TL4	OPCAPN	7.00		
TL5	OBJ	-7.00	LABLO5	-1.00
TL5	OPCAPN	7.00		
TL6	OBJ	-7.00	LABLO6	-1.00
TL6	OPCAPN	7.00		
PL1	OBJ	-6.00	LABLO1	-1.00
PL1	PELAB1	1.00	OPCAPN	6.00
PL2	OBJ	-6.00	LABLO2	-1.00
PL2	PELAB2	1.00	OPCAPN	6.00
PL3	OBJ	-6.00	LABLO3	-1.00
PL3	PELAB3	1.00	OPCAPN	6.00
PL4	OBJ	-6.00	LABLO4	-1.00
PL4	PELAB4	1.00	OPCAPN	6.00
PL5	OBJ	-6.00	LABLO5	-1.00
PL5	PELAB5	1.00	OPCAPN	6.00
PL6	OBJ	-6.00	LABLO6	-1.00
PL6	PELAB6	1.00	OPCAPN	6.00
SL1	OBJ	-4.00	LABLO1	-1.00
SL1	SULAB1	1.00	OPCAPN	4.00
SL2	OBJ	-4.00	LABLO2	-1.00
SL2	SULAB2	1.00	OPCAPN	4.00
SL3	OBJ	-4.00	LABLO3	-1.00
SL3	SULAB3	1.00	OPCAPN	4.00
SL4	OBJ	-4.00	LABLO4	-1.00
SL4	SULAB4	1.00	OPCAPN	4.00
SL5	OBJ	-4.00	LABLO5	-1.00
SL5	SULAB5	1.00	OPCAPN	4.00
SL6	OBJ	-4.00	LABLO6	-1.00
SL6	SULAB6	1.00	OPCAPN	4.00
NS	SHARBA	1.00	LABSH1	-90.93
NS	LABSH2	-90.93	LABSH3	-90.93
NS	LABSH4	-90.93	LABSH5	-90.93
NS	LABSH6	-90.93	SULAB1	-19.07
NS	SULAB2	-19.07	SULAB3	-19.07
NS	SULAB4	-19.07	SULAB5	-19.07
NS	SULAB6	-19.07		
BO1	OBJ	-0.10	CREDLI	1.00
BO1	OPCAPI	1.00	OPCAPN	-1.00
BO2	OBJ	-0.15	CREDLI	1.00
BO2	OPCAPN	-1.00		
BI1	OBJ	-0.10	CREDLI	1.00
BI1	INVCAP	1.00	INVCAN	-1.00
BI2	OBJ	-0.15	CREDLI	1.00
BI2	INVCAN	-1.00		

Table C-11. Continued

09 NOVEMBER 1978			NERDC --- CARD LIST UTILITY	
IP	OBJ	-2.25	CROPLB	-1.00
IP	PASTUR	1.00	LABL05	5.81
IP	LABL06	12.75	OPCAPN	2.25
IF	OBJ	-3.75	PASTUR	-1.00
IF	FALLOW	1.00	LABL05	6.34
IF	LABL06	13.07	OPCAPN	5.75
SLS	CROPLB	10.00	SHLAND	-10.00
SLS	SHARBA	-1.00		
SC	OBJ	1646.69	SHLAND	10.00
SC	LABSH1	52.45	LABSH2	261.65
SC	LABSH3	87.23	LABSH4	58.52
SC	LABSH5	70.05	LABSH6	47.15
SC	OPCAPN	1321.04		
STL2	OBJ	-3.50	LABSH2	-1.00
STL2	OPCAPN	3.50		
RHS				
Z3	CROPLA	1.07	CROPLB	43.13
Z3	PASTUR	246.56	FALLOW	101.41
Z3	LABCON	125.00	FALAB1	32.90
Z3	FALAB2	32.90	FALAB3	32.90
Z3	FALAB4	32.90	FALAB5	32.90
Z3	FALAB6	32.90	PELAB1	30.93
Z3	PELAB2	30.93	PELAB3	30.93
Z3	PELAB4	30.93	PELAB5	30.93
Z3	PELAB6	30.93	OPCAPI	15600.00
Z3	INVCAP	15600.00	CREDLI	118508.61
ENDATA				

Table C-12. Structure of the large landowner linear programming model

		SC1	SC2	SC3	SC4	SC5	TF1	TF2	TF3	TF4	TF5	TF6	TF7	TF8	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	CB1	CB2	CC1	CC2	CM	TL1	TL2	TL3	TL4	TL5	TL6	OL1	OL2	OL3	OL4	OL5	OL6	SL1	SL2	SL3	SL4	SL5	SL6	Z1
CEJ	N	-T	-T	-B	-A	-A									C	C	C	C	C	C	B	C						-A	-A	-A	-A	-A	-A	A	A	A	A	A	A	A	A	A	A	A	A	
TPCCTT	G	C					-1																																							
TPCCT1	G				C			-1																																						
TPCCT3	G					C			-1																																					
TPPEA1	G				C					-1																																				
TPPEA3	G					C					-1																																			
TPCCRN	G		C									-1																																		
TPCCR1	G				C								-1																																	
TPCASS	G			D										-1																																
BACCTT	E						1								-C																															
BACCT1	E							1								-C																														
BACCT3	E								1								-C																													
BACEA1	E									1								-C					-1																							
BAPEA3	E										1								-C					-1																						
BACCRN	E											1								-C					-1																					
BACCR1	E												1								-C					-1																				
BACASS	E													1								-D					-1																			
BRCCNS	G																						1	1																						C
CCCCNS	G																								1	1																				B
CACCNS	G																										1																			C
CRCPLA	E	1	1	1	1	1																																								A
FALAB1	L	T	A	B	A	A																						-1						1												B
FALAB2	L	A	B	B	B	B																							-1						1											B
FALAB3	L	A	A	B	A	A																								-1						1										B
FALAB4	L	A	A	A	A	A																									-1						1									B
FALAB5	L	A	A	A	A	A																										-1						1								B
FALAB6	L	A	A	A	A	A																											-1						1							B
LABCCN	L																												1																	C
SULAB1	L																																							1						B
SULAB2	L																																								1					B
SULAB3	L																																									1				B
SULAB4	L																																										1			B
SULAB5	L																																											1		B
SULAB6	L																																												1	B
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APPENDIX D
TIME SERIES DATA FOR YIELDS, CURRENT PRICES, PRICE INDEX, AND CONSTANT PRICES

Table D-1. Average yield of kilograms per hectare of major crops for the Seridó Region, Rio Grande do Norte, Brazil, 1965/1976

Crop	Type of land	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Single crop													
Cotton	"B"	285	308	295	334	123	108	220	370	398	254	244	241
Rice	"A"	740	691	935	779	711	427	841	702	886	962	937	382
Beans	"A"	485	559	896	683	690	335	920	381	356	623	1,027	229
Corn	"B"	367	478	945	567	522	139	739	542	200	434	422	172
Cassava[a]	"B"	2,400	4,000	5,000	6,000	5,000	2,000	2,414	4,742	7,579	7,648	7,891	7,942
Sweet potato	"A"	6,842	7,760	8,114	8,110	8,097	7,426	7,946	7,602	9,318	8,015	8,011	7,819
Mixed crop													
Cotton	"B"	262	230	177	205	212	70	233	210	259	178	159	157
Beans		297	338	544	413	418	263	562	432	417	251	293	117
Corn		330	430	852	511	471	127	664	482	492	391	381	154
Beans	"A"	243	280	448	342	345	168	460	191	178	312	514	115
Corn		276	359	709	426	392	105	555	407	150	326	317	129
Cotton	"B"	300	287	221	256	264	88	290	261	300	222	199	196
Beans		311	358	575	438	443	280	592	454	438	264	311	121

[a]1965/1973--Average yield for the County of Florania; 1974/1976--Average yield for the State of Rio Grande do Norte.

SOURCE: Barbosa [1976, p. 59]; FIBGE; CEPA-RN.

Table D-2. Average prices received by farmers of major farm enterprises for the state of Rio Grande do Norte, Brazil, 1966/1976

Product	Unit	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Cotton	Cr$/kg	0.30	0.34	0.47	0.49	0.67	1.04	1.00	1.41	2.27	2.46	5.00
Rice	Cr$/kg	0.26	0.24	0.31	0.35	0.47	0.92	0.74	0.85	1.24	1.87	2.07
Beans	Cr$/kg	0.48	0.41	0.29	0.65	1.20	1.32	0.91	1.52	2.22	2.48	6.11
Corn	Cr$/kg	0.18	0.20	0.19	0.26	0.46	0.57	0.47	0.50	0.78	1.03	1.61
Cassava	Cr$/ton	30.78	40.24	39.56	38.94	83.18	117.69	107.94	105.77	129.95	338.40	616.00
Cattle	Cr$/kg	1.11	1.52	1.84	1.96	2.20	3.39	4.17	5.99	9.81	9.51	11.52
Milk	Cr$/l	0.24	0.29	0.33	0.37	0.44	0.57	0.67	0.81	1.22	1.65	2.29

SOURCE: Fundacão Getulio Vargas (F.G.V.)[1973 and 1977].

Table D-3. Domestic price index and conversion factors, 1965/1976, Base 1965/1967 = 100

Year	Domestic price index	Conversion factor
1965	72.3	5.1590
1966	99.7	3.7412
1967	128.0	2.9141
1968	159.0	2.3459
1969	192.0	1.9427
1970	230.0	1.6217
1971	277.0	1.3466
1972	324.0	1.1512
1973	373.0	1.0000
1974	480.0	0.7771
1975	613.0	0.6085
1976	866.0	0.4307

SOURCE: Fundacão Getúlio Vargas (F.G.V.) [1973 and 1977].

Table D-4. Constant prices for major agricultural products for the state of Rio Grande do Norte, Brazil, 1965/1976[a]

Product	Unit	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Cotton	Cr$/kg	1.12	0.99	1.10	0.95	1.09	1.40	1.15	1.41	1.76	1.50	2.15
Rice	Cr$/kg	0.97	0.70	0.73	0.68	0.76	1.24	0.85	0.85	0.96	1.14	0.89
Beans	Cr$/kg	1.80	1.19	0.68	1.26	1.95	1.78	1.05	1.52	1.72	1.51	2.63
Corn	Cr$/kg	0.67	0.58	0.44	0.50	0.74	0.77	0.54	0.50	0.61	0.63	0.69
Cassava	Cr$/ton	115.15	117.26	92.80	75.65	134.89	158.48	124.26	105.77	100.98	205.92	265.31
Beef	Cr$/kg	4.15	4.43	4.32	3.81	3.57	4.56	4.80	5.99	7.62	5.79	4.96
Milk	Cr$/l	0.90	0.84	0.77	0.72	0.71	0.77	0.77	0.81	0.95	1.00	0.99

[a]Constant 1973 prices.

SOURCE: Tables D-2 and D-3.

Table D-5. Gross returns of major farm enterprises in cruzeiros, Sertao do Seridó, 1966/1976

Crop	Type of Land	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Single crop												
Cotton	"B"	345.69	292.28	368.26	117.09	117.35	308.10	425.94	561.18	448.06	365.25	518.99
Rice	"A"	672.14	653.92	566.51	483.44	325.46	1,054.28	598.03	753.10	926.99	1,066.21	340.57
Beans	"A"	1,003.84	1,070.52	464.65	871.30	651.92	1,635.31	399.13	541.12	1,074.78	1,549.83	602.63
Corn	"B"	321.89	550.76	252.72	263.66	103.69	567.23	293.26	100.00	263.06	264.49	119.27
Cassava	"B"	460.62	586.32	556.82	378.24	269.79	382.57	589.24	801.63	772.33	1,624.89	2,107.10
Consortium												
Cotton Beans Corn	"B"	1,154.68	1,321.89	734.76	967.54	682.61	1,834.93	955.10	1,245.03	984.01	918.96	752.78
Beans Corn	"A"	744.57	948.48	422.54	633.65	405.26	1,243.65	420.30	345.56	735.85	974.35	392.08
Cotton Beans	"B"	965.01	095.96	580.23	810.71	640.51	1,458.42	776.07	1,088.76	847.05	767.21	740.51
Cattle[a]	---	565.54	579.16	553.84	496.23	473.51	574.80	596.80	712.12	888.61	735.28	657.22

[a]In terms of animal-units.

SOURCE: Tables D-1 and D-4.

Table D-6. Expected gross returns, variable costs, and gross margins of major farm enterprises, Sertao do Seridó

Crop	Type of land	Expected gross returns	Variable costs[a]	Gross margins
Single crop				
Cotton	"B"	351.65	0.33	351.32
Rice	"A"	676.42	2.24	674.18
Beans	"A"	896.82	22.78	874.04
Corn	"B"	281.82	0.89	280.93
Cassava	"B"	775.41	126.99	648.42
Mixed crops				
Cotton Beans Corn	"B"	1,050.21	2.75	1,047.46
Beans Corn	"A"	660.57	6.17	654.40
Cotton Beans	"B"	870.95	3.32	867.63
Cattle[b]	---	621.19	375.72	245.47

[a]Cost of labor is not included.

[b]In terms of animal-units.

SOURCE: Tables D-4 and D-5; SUDENE [1976].

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Between 1967 and 1969, he worked as a research assistant in Agricultural Economics at IPEA and GEIPOT (federal government planning and research agencies). Following his graduation in 1968, he joined the staff at the Research Institute of IPEA (INPES) where he is presently an agricultural economist. In addition, he is a former lecturer in the Department of Economics of the Pontifícia Universidade Católica do Rio de Janeiro (1971-1972) and a former consultant for Osára Engenharia Ltda (1968) and Agrotecnica Ltda (1971). He is a member of the American Agricultural Economics Association, Southern Agricultural Economics Association, Brazilian Agricultural Economics Association (SOBER), and Instituto de Economistas do Rio de Janeiro.

He is married to Maria Lucia Vasconcelos Ferreira and has a daughter, Solange.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

W. W. McPherson

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Graduate Research Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Max R. Langham

Max R. Langham
Professor of Food and Resource Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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